Exploratory Study

# Assessment of OSW's 35% Municipal Solid Waste Recycling National GPRA Goal for 2005

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# Disclaimer

This document presents the findings of an exploratory study conducted Summer 2003, involving a literature review, secondary data collection, and secondary analysis (i.e. analysis of reports, documents, books, and journal articles authored by other persons with goals generally different from the objectives of this study). Because of its exploratory nature, the contents of this study document do not represent official US EPA policy, nor do the references contained in this document constitute endorsement of particular authors, organizations, methods, information or data. The individual author identified on the title page is solely responsible for the scope, design, analyses, findings, format and contents of this document.

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# Summary

OSW's RCRA solid waste authority assigns resource recovery (e.g. waste recycling) responsibilities to state government planning (i.e. RCRA Subtitle D resource recovery), and to the US Dept of Commerce (i.e. RCRA Subtitle E development of materials recovery technologies & commercial markets). However, in 1988, OSW challenged the nation to recycle 25% of MSW by 1992, and in 1996 proposed a 35% goal for 2005. The purpose of this exploratory study is to assess the feasibility and economics of achieving the 35% goal relative to the 2000 national MSW recycling baseline of 30% to 32% (i.e. 70 to 130 million tons recycled of 232 to 409 million tons generated, respectively), using existing published data on US state- and US city-wide MSW recycling performance measures.

As of 2000, state MSW recycling rates ranged from 1% (OK) to 59% (DE), and the 25 largest US cities ranged from 2% (Dallas) to 56% (San Francisco). Statewide MSW curbside recycling program population coverage ranged from 0% (AK) to 100% (CT), averaging 52% of the US population.

Based on +/-1 standard deviation statistical intervals from a pooled data sample of 30 city-wide MSW recycling program costs (@$35 to $162/ton), and five recycling benefit categories (@$226 to $544/ton), this study estimates that an incremental $420 to $1,900 million in annual cost is needed to recycle an additional 12 million tons/year of MSW to reach the 35% goal, which would generate $2.3 to $4.6 billion in additional annual net benefits, representing a benefit-cost ratio (BCR) of 3.4 to 6.4.

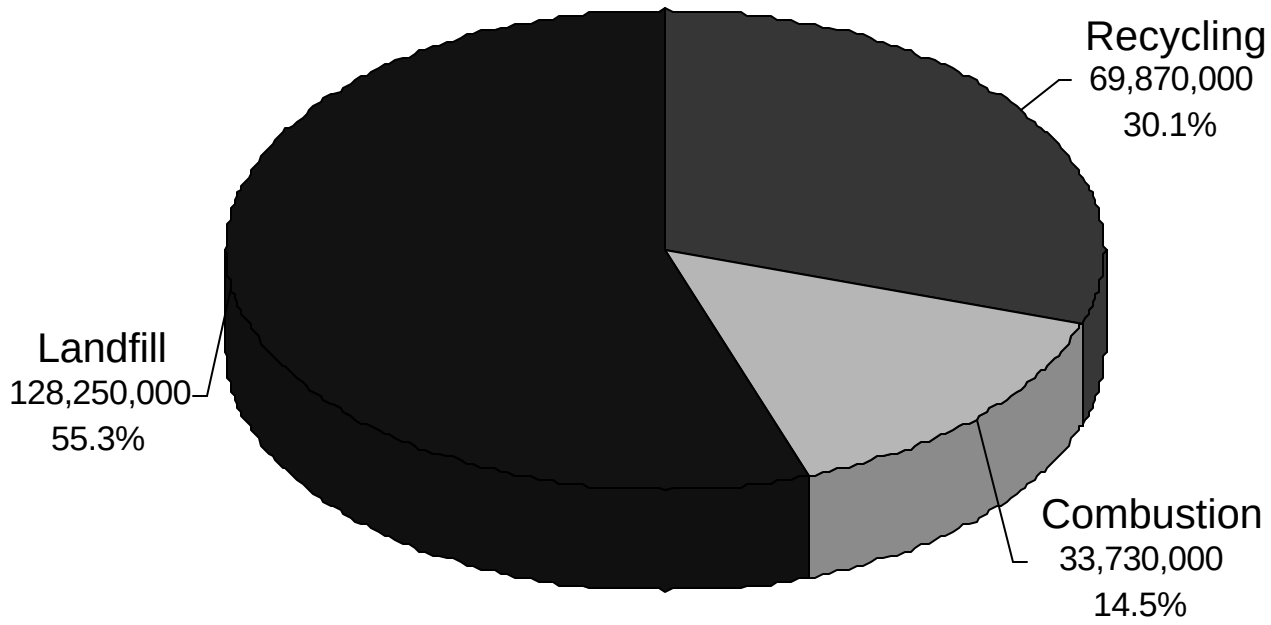
This study projects an economically-beneficial recycling "net cost" threshold of 225$/ton (for minimum BCR =1), and projects a future potential national MSW recycling rate ranging between 40% to 45% based on meeting current unmet statewide goals, to 46% to 49% from expanded program coverage to all large + small urban populations.

# I. OSW MSW RECYCLING POLICY ISSUE:

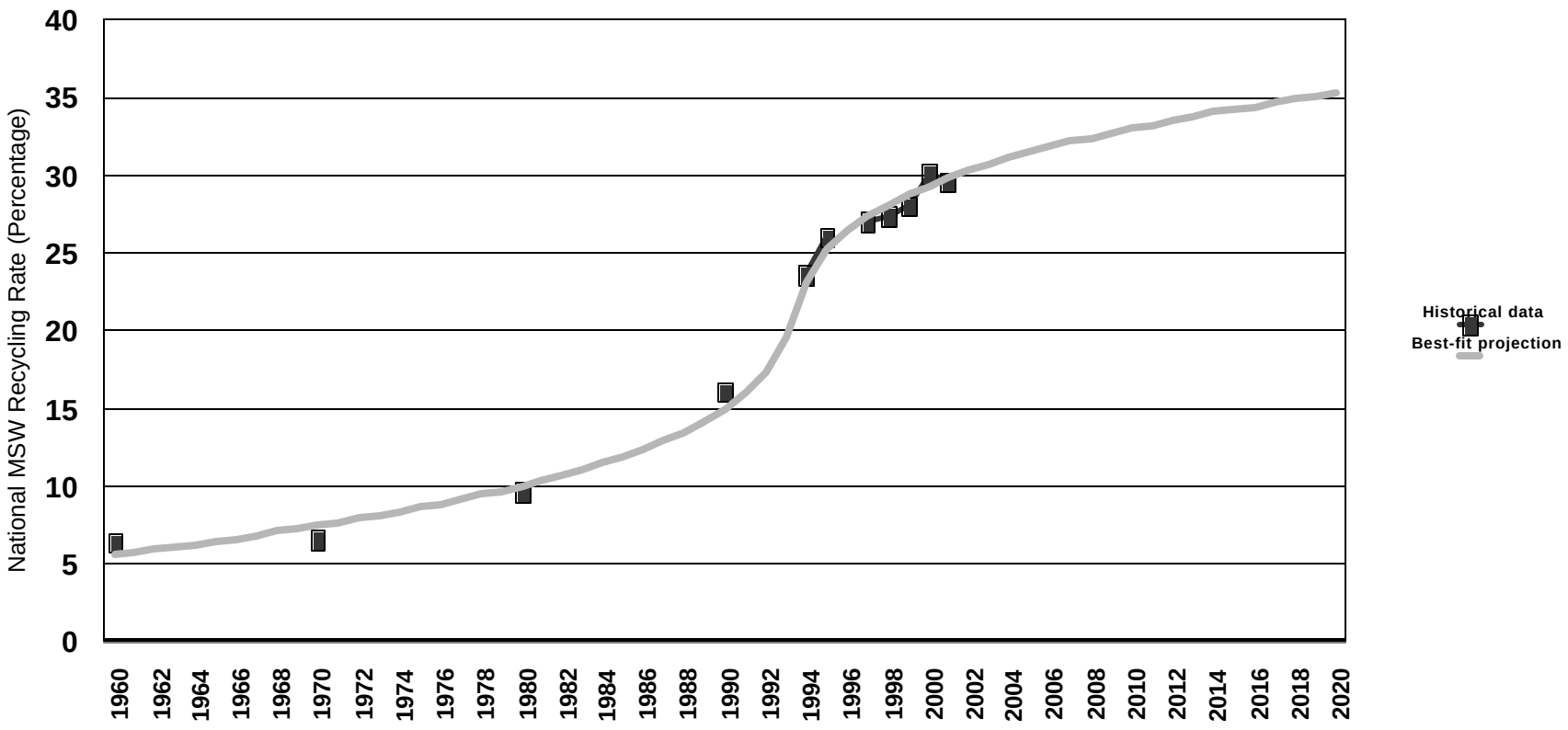
Is OSW's Year 2005 GPRA National Goal of 35% MSW Recycling Achievable?

# Big Picture Snapshot of MSW Management (US Year 2000)

**Management of Municipal Solid Waste**
**Based on 231.85 Million Total Tons MSW Generated (US 2000)**
**Source: USEPA Office of Solid Waste, EPA-530-R-02-001 ("Franklin Report"), June 2002, Table 29, p.126**

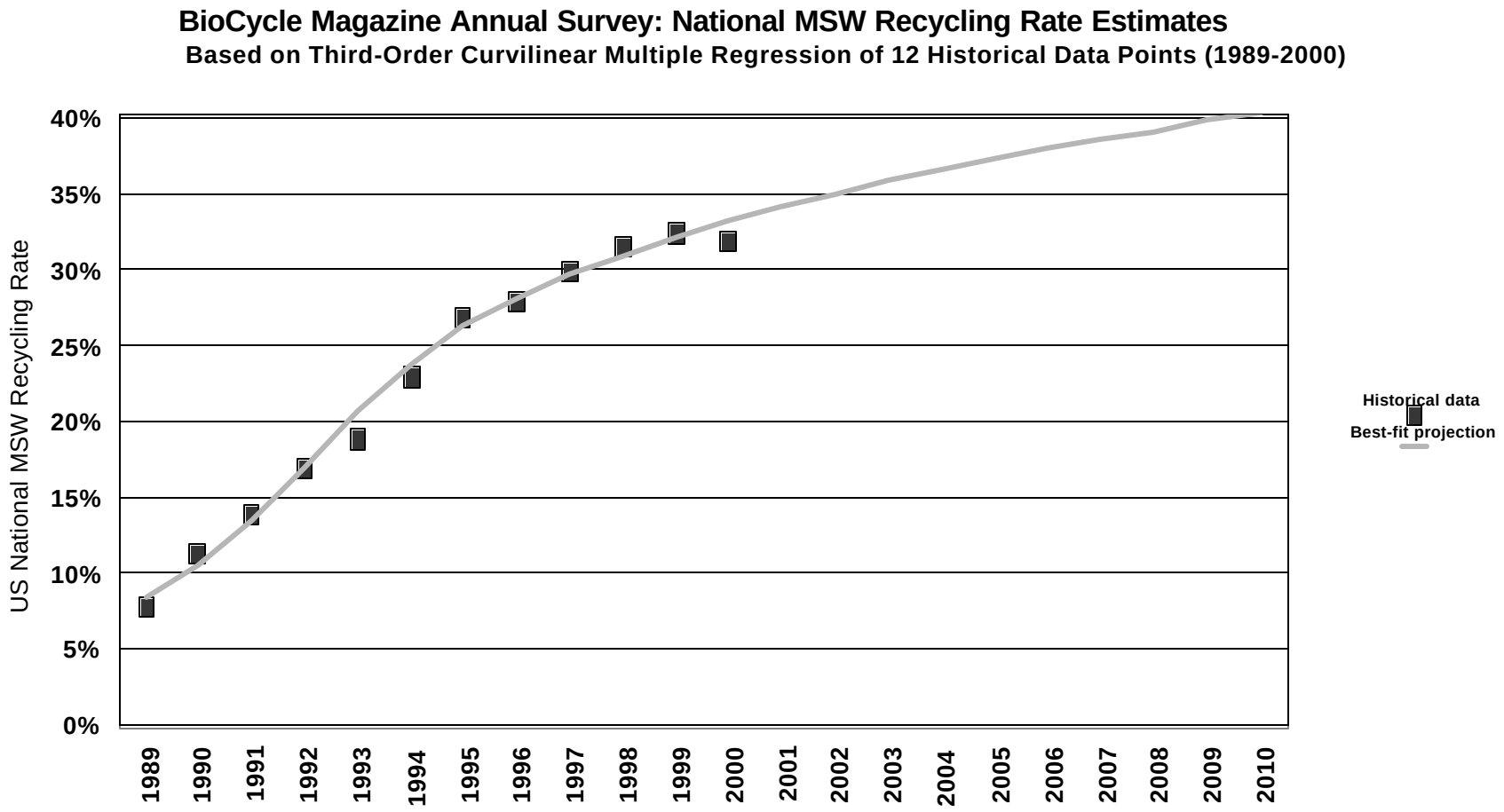


# Future Projection #1 of 2:
## -- Franklin trendline suggests 35% in 2018 w/out re-measurement or stimulation



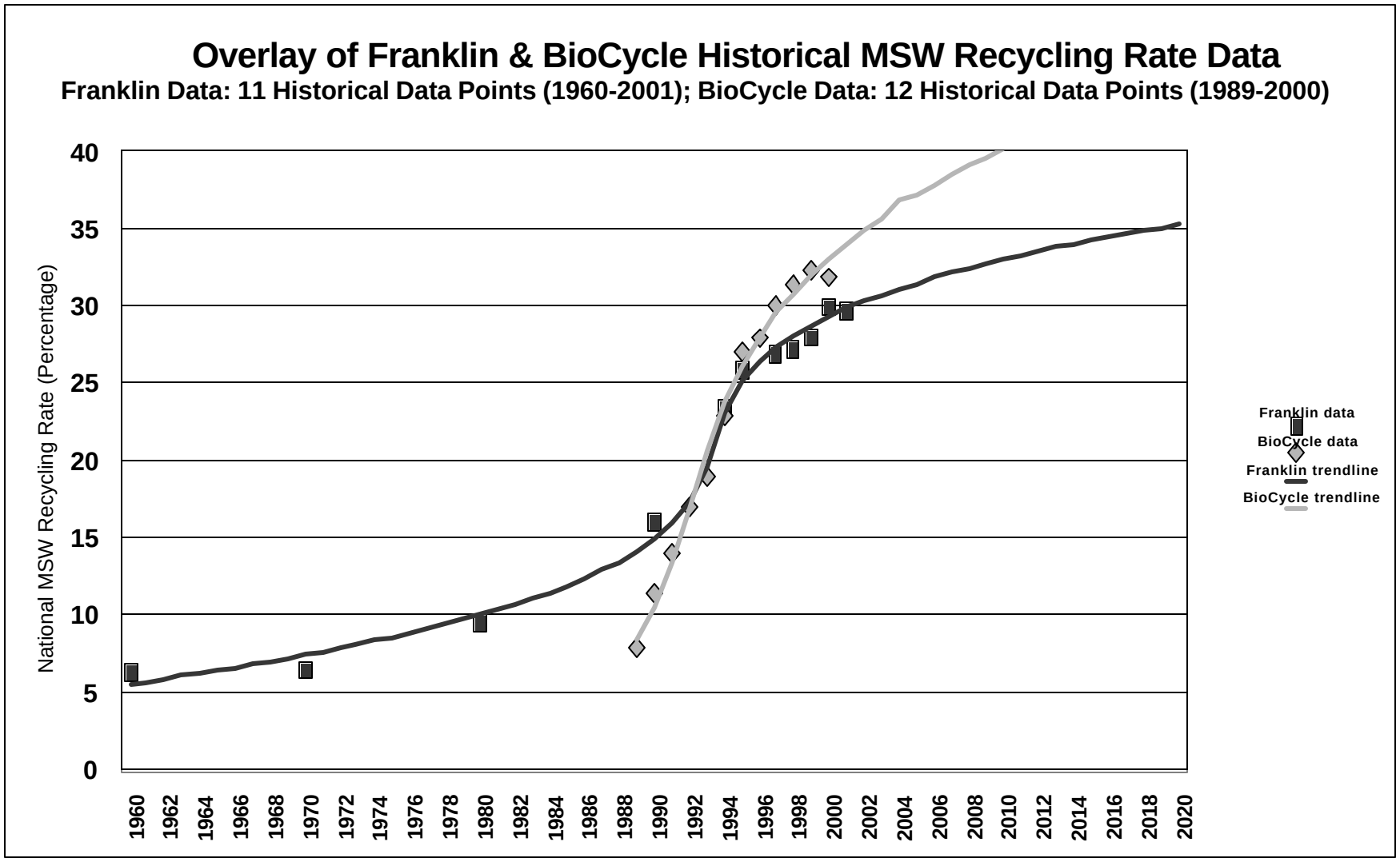

Trend line "goodness-of-fit" R-squared statistic: 1st-order (straight-line) = 90.0%; 2nd-order (parabolic curve) = 94.3%; 3rd-order (S-curve) = 97.4% (100% = perfect fit of trendline to data).
Historical data source: USEPA Office of Solid Waste (Franklin Associates Inc. contractor), EPA-530-R-02-001, June 2002, Table 2, page 33; http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm

# Future Projection #2 of 2:
# -- BioCycle magazine historical trendline suggests 35% by year 2003!!!




Trend line "goodness-of-fit" R-squared statistic: 1st-order (straight-line) = 95.6%; 2nd-order (parabolic curve) = 97.2%; third-order (S-curve) = 98.3%.
Historical data source: "13th Annual BioCycle Nationwide Survey", BioCycle magazine, Dec 2001, Table 1, page 43; http://www.environmental-center.com/articles/article1130/article1130.htm#article2

# Overlay of Franklin & BioCycle Historical Data Series



# Which Future Recycling Rate Projection is "Correct"?

## Franklin Associates data

- 35% recycling by year **2018**

Baseline (2000 data year; all states):

- 30.1% MSW recycled
- 231.9 million TPY MSW generated = 0.82 TPY/person
- 69.9 million tons recycled
- Increment to 35% = (35%-30.1%) x 69.9 = 11.4 million tons/year

Data (Measurement) Scope:

- Includes:
  - Composting (but not backyard composting)
  - Commercial
  - Institutional
  - Industrial office/food/packaging
- Excludes:
  - Construction & demolition debris
  - Biosolids (sewage sludge)
  - Scrap autos
  - Motor oil
  - Agricultural
  - Industrial process wastes

## BioCycle magazine data

- 35% recycling by year **2003**

Baseline (2000 data year; 47 states):

- 31.9% MSW recycled
- 409.0 million TPY MSW generated = 1.45 TPY/person
- 130.5 million tons recycled
- Increment to 35% = (35%-31.9%)x409.0 = 12.7 million tons/year

Data (Measurement) Scope:

- Excludes:
  - Composting
- Includes:
  - C&D debris (wood, asphalt, concrete)
  - Biosolids (9 states)
  - Scrap autos (2 states)
  - Motor oil (11 states)
  - Agricultural (14 states)
  - Commercial (47 states)
  - Institutional (43 states)
  - Industrial process residuals (24 states)

# Benchmark: Recent International MSW Recycling Rates

Europe:

- Austria (1999) 64%
- Belgium (1998) 52%
- Germany (1999) 48%
- Netherlands (1999) 47%
- Denmark (1999) 39%
- Finland (1997) 33%
- Sweden (1998) 33%
- Spain (1999) 27%
- Italy (1997) 16%
- France (1998) 14%
- U. Kingdom (1999) 11%
- Portugal (1999) 9%
- Greece (1997) 8%

Other Countries:

- Canada (2000) 24%
- Japan:
  - 1992 4%
  - 1995 10%
  - 2002 65%

Note: The basket of wastes included in recycling rates varies between countries.

# International MSW Recycling Ideologies: Two Contrasting Examples

- Pro (Japan): In June 2000, the Government of Japan began implementing "*The Basic Plan for Establishing a Recycling-Based Society*", providing a 10-year program to promote comprehensive and systematic policies aimed at changing unsustainable patterns of production and consumption: "to reduce the amount of resources that are removed from nature as much as possible, and to reduce the amount of things that are finally discarded in nature as much as possible by inputting things once used in society as recycled resources." [http://www.env.go.jp/recycle/circul/kihonho/law-e.pdf].

- Con (Sweden): In Nov 1999, the Swedish Government Finance Department published a report titled "*Recycling: Not Worth The Effort*", which concluded: "The social value of recycling beyond the level motivated by market forces rests solely on its positive contribution towards environmental standards, or to sustainability if depletion is a problem. Environmental evaluations reveal that paper burning and glass and metal landfilling, for example, are superior to recycling in environmental terms, so the net effect of additional recycling of these waste flows is detrimental to the environment. Cost-effective policies to improve environmental conditions should aim at directly enhancing these conditions, and only in rare cases would recycling across the board emerge as an efficient policy tool" [http://finans.regeringen.se/eso/PDF/ds99_66.pdf].

# II. ASSESSMENT OF MSW RECYCLING

# Required Orientation for National Assessment of Recycling

The Resource Conservation & Recovery Act (RCRA) assigns primary responsibility for recycling and all non-hazardous waste policy decisions to state governments. Consequently, recycling initiatives and recycling programs in the US are not uniform, since they are designed and implemented at the state and local levels. This in turn means that **any economic analysis of recycling must rely on local observations and, to assure that the results can be generalized, must control for community- and region-specific influences and factors**.

Source: Scott Callan & Janet Thomas, Bentley College, "The Impact of State and Local Policies on The Recycling Effort", Eastern Economic Journal, Vol. 23, No. 4, Fall 1997, p.411.

# MSW Recycling Goal Assessment Methodology

- Timeframe: Initial two-month timeframe (April & May 2003) set by OSW MISWD recycling team, for EMRAD to conduct this assessment; scope of EMRAD part-time work on this study expanded thru Aug 2003, as new literature sources became available from inter-library loan sources.

- Scope: Evaluation "Option 2" was initial EMRAD study scope & framework for this assessment; evaluation scope expanded to include internet info/data search (per "Option 3"), and benefit-cost analysis (per "Option 4"); Appendix C contains the four study plan options.

- Staff: One EMRAD staff economist (Mark Eads) conducted this project in-house (no contractor support). Information contributions by MISWD staff, MISWD contractor (Franklin Associates), and OSW Regional Implementation Team (RIT).

- Data: Recycling assessment limited to secondary information sources on recycling baseline, recycling infrastructure, & recycling costs/benefits (no new data collected).

# Secondary Information Sources Consulted/Collected

Sources:

- MISWD staff
- Franklin Associates
- EMRAD staff
- OSW Regional Implementation Team (RIT) conference call
- Internet search
- EPA HQ library
- Interlibrary loans

Categories:

- Peer-reviewed academic journal articles
- Recycling news
- Trade/industry magazines
- EPA reports
- White papers (e.g. local/state govt's, NGOs)
- State technical guidance
- Case studies (e.g. cities, recovered material markets)
- US regional studies (e.g. NE)
- International items

# ASSESSMENT ISSUE #1: Recycling Rate Measurement

# Caveat Emptor:
# Recycling Rate Measurement Variability

"Currently, not everyone defines recycling or the processes that constitute recycling in the same way. Definitions of MSW [municipal solid waste] also vary. There is no standard approach for how or where to collect the needed data. **The methods used to calculate a recycling rate also differ from one area to another**. All of these factors can make it difficult to collect and analyze data and to compare the effectiveness of recycling programs from one region to another."

Source: USEPA Office of Solid Waste, "Measuring Recycling: A Guide for State and Local Governments", EPA-530-R-97-011, Sept 1997, 160 pp.

http://www.epa.gov/epaoswer/non-hw/recycle/recmeas/download.htm

# Recycling & Related Concepts (USEPA definitions)

- Waste recycling: the series of activities by which discarded materials are collected, sorted, processed, and converted into raw materials and used in the production of new products; excludes the use of these materials as a fuel substitute or for energy production.
- Waste generation: amount of materials and products that enter the wastestream (e.g. from residential, business/commercial, institutional, and industrial sources) before recycling, reuse, composting, landfilling, or combustion takes place.
- Waste reuse: use of a product or component of waste in its original form more than once (e.g. refilling glass or plastic bottles, repairing pallets).
- Waste recovery: removal (capture) of materials from the wastestream for diversion from disposal into recycling, composting, or reuse.
- Discards: materials remaining in wastestream after recovery.
- Waste disposal: ultimate disposition (emission) of discards (non-recovered materials) into the environment (air, land, water) as “sink”.

# Standard MSW Recycling Rate (USEPA definition)

$$\text{MSW recycling rate (\%)} = \frac{\text{(quantity MSW recycled)}}{\text{(quantity MSW generated)}} \times 100$$

# Recycling Rate Measurement Issues Implied From 14 May 2003 Franklin Assoc. Briefing to OSW

- Recycling Sources: EPA's scope for MSW not exclusively "municipal"; includes commercial, institutional, & some industrial (e.g. wood pallets); could be revised as four separate category sensitivity analyses.

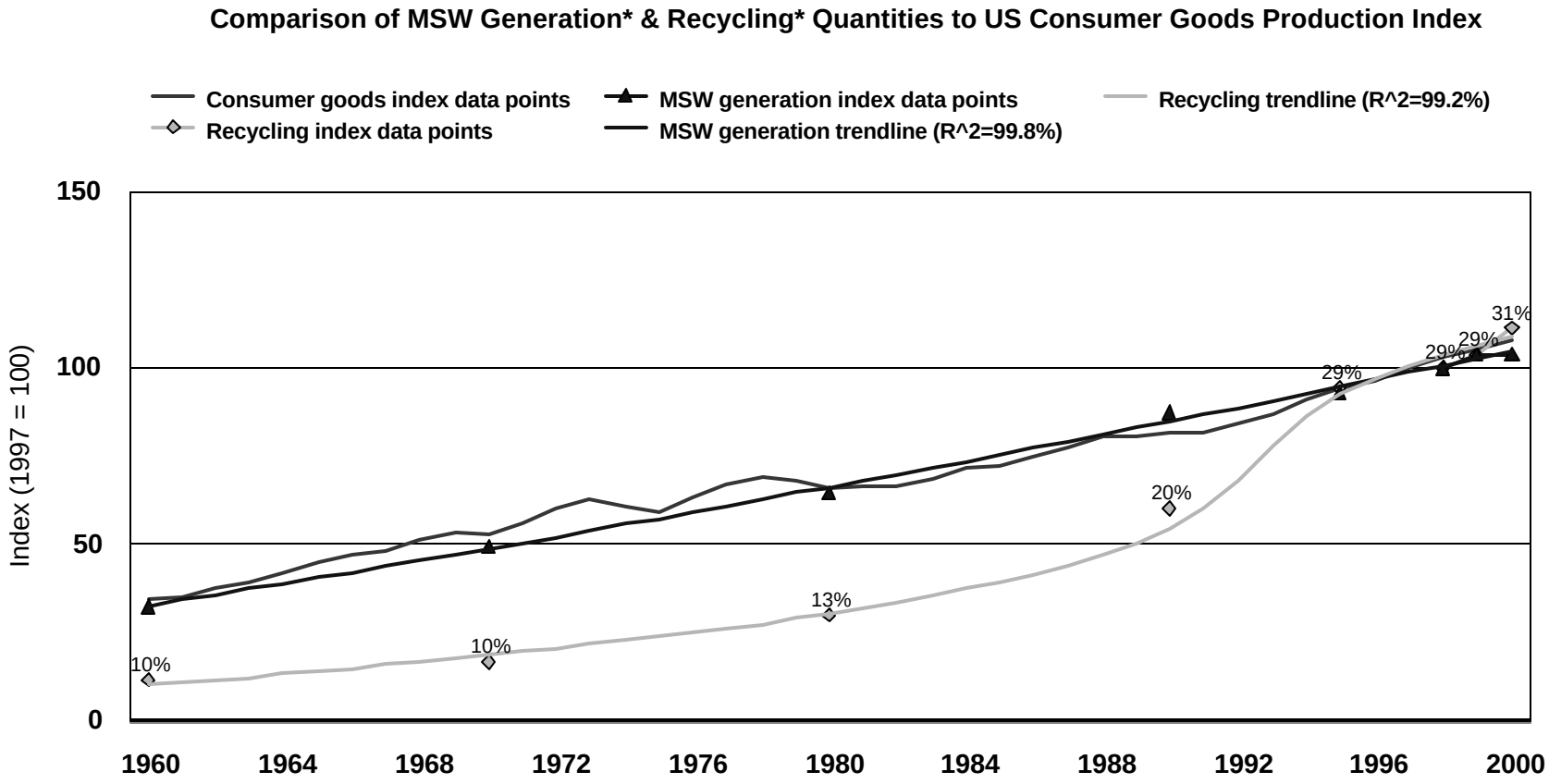
- Recyclable Materials: Excludes a number of waste streams that others may classify as MSW: construction & demolition debris, used oil, medical waste, pre-consumer waste; could be included as sensitivity analysis.

- Materials Reuse/Energy: Excludes materials reuse (e.g. retreaded tires), source reduction substitution (textiles or container reuse), waste-to-energy (e.g. pallets), backyard composting, and land applications; could be included as sensitivity analysis.

- Assumptions: Some key numerical assumptions for estimating the annual recycling rate, were formulated in early-1990s; could be updated.

- Uncertainty: Possible to introduce uncertainty ranges in numerical values of some key assumptions, and carry-thru ranges to annual recycling rate estimates, rather than single point estimates each year.

# Recycled Quantity Divided by MSW Generated = "Recycling Efficiency"
# MSW Generated Divided by Consumer Goods Production = "Recycling Availability"




* MSW generation index in this table only includes material products; excludes yard trimmings, food, misc inorganics (soil, stones, concrete), & other non product materials.
MSW generation & recycling data source: EPA-530-R-02-001 (Tables 1 & 2); http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm
IPI data source: Economic Report of the President, Feb 2003, Table B-52; http://w3.access.gpo.gov/usbudget/fy2004/pdf/2003_erp.pdf

# ASSESSMENT ISSUE #2: Recycling Rate Stimulation

# 2A. MSW Recycling Baseline (2000)

2A.1 Statewide Recycling Rates & Goals
2A.2 City Recycling Rates
2A.3 Materials Recycled
2A.4 Recent Policies & Options for Affecting Rates

# 2A.1
# Statewide Recycling Rates & Goals

# MSW Recycling Rates for States (2000)

1. DE 59%
2. AR 45%
3. NY 42%
4. CA 42%
5. MN 42%
6. ME 40%
7. OR 39%
8. NJ 38%
9. MA 38%
10. MO 38%
11. MD 37%
12. WI 36%
13. IN 35%
14. WA 35%
15. TX 35%
16. IA 35%
17. TN 34%
18. PA 33%
19. VT 33%
20. SC 31%
21. KY 30%
22. VA 29%
23. FL 28%
24. IL 28%
25. NC 26%
26. WV 25%
27. RI 24%
28. HI 24%
29. AL 23%
30. NE 23%
31. CT 23%
32. NH 21%
33. OH 21%
34. MI 18%
35. AZ 17%
36. LA 17%
37. MS 16%
38. NV 14%
39. ND 11%
40. WY 10%
41. NM 9%
42. CO 9%
43. KS 9%
44. AK 8%
45. UT 5%
46. OK 1%

Source: BioCycle magazine, Dec 2001, Table 3, page 45

Note: states vary in what they include (measure) in their recycling rates.

Data not available from source for GA, ID, MT, SD

# Provision of MSW Recycling Services (US 1995)

| Provider of Service | National Prevalence* Curb | Com | Drpoff | Proc |
|---|---|---|---|---|
| ■ Local government program | 40% | 14% | 16% | 9% |
| ■ Local gov't contractor | 42% | 15% | 25% | 30% |
| ■ Gov't franchise to single firm | 9% | 6% | 4% | 5% |
| ■ Private firms w/out gov't $ | 16% | 47% | 8% | 7% |

* Source: Based on 1995 sample of 1,071medium-sized north-central cities with MSW recycling programs consisting of: (1) residential curbside collection, (2) commercial collection, (3) drop-off facilities, and/or (4) recyclables processing facilities (Resources for the Future, Discussion Paper 02-35, June 2002, Table 2, p.17).

Curb = residential curbside collection
Comm = commercial collection
Drpoff = drop-off facilities
Proc = Recyclables processing

# State MSW Landfill Disposal Bans (2000)

| Material Category | Nr. states w/ban | % states |
|---|---|---|
| ▪ Vehicle batteries | 32 | 63% |
| ▪ Whole tires | 30 | 59% |
| ▪ Yard trimmings | 21 | 41% |
| ▪ Motor oil | 19 | 37% |
| ▪ White goods | 17 | 33% |
| ▪ Other materials | 12 | 24% |

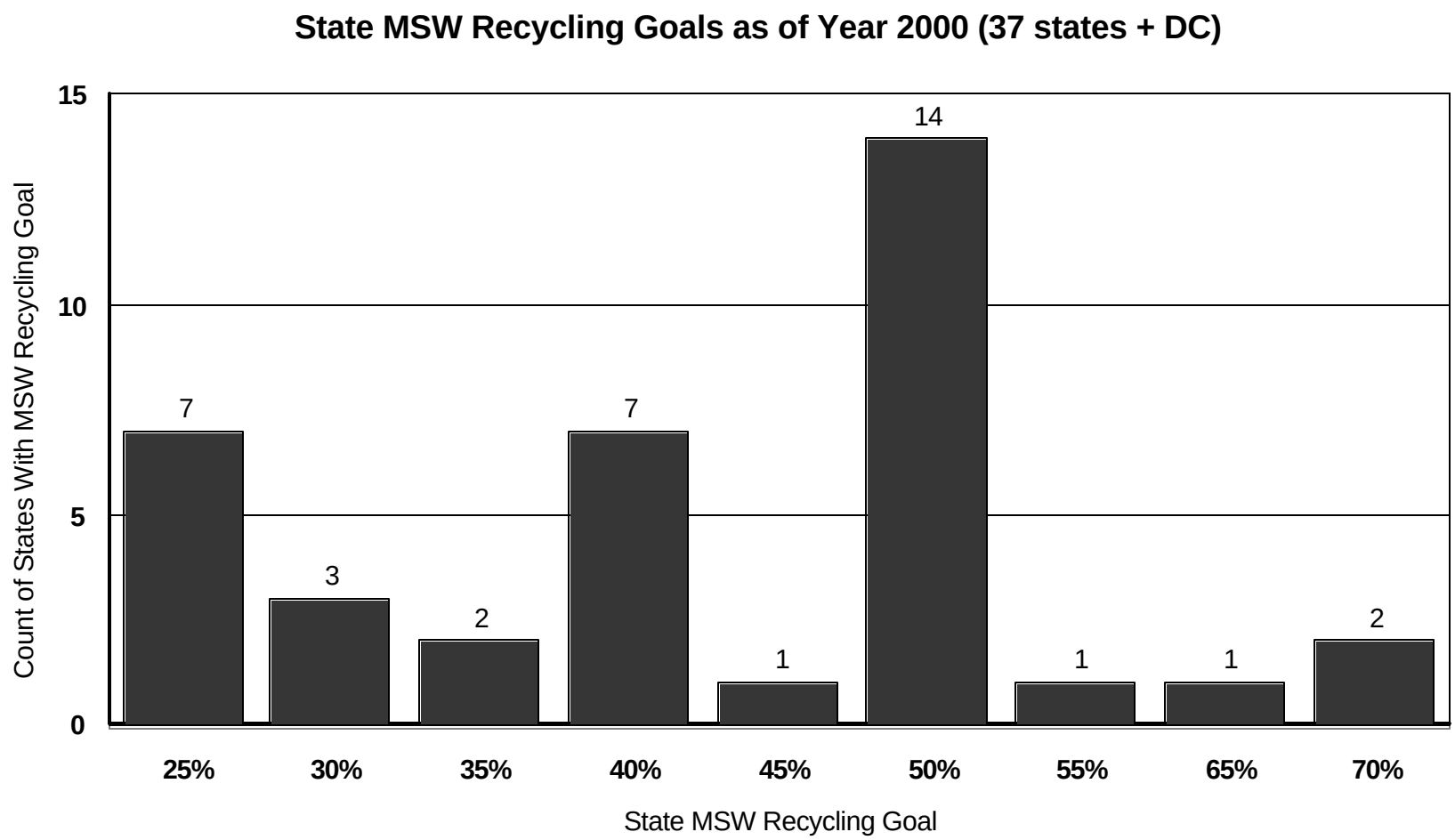
Source: BioCycle magazine, Dec 2001, Table 12, p.51 (40 states have at least one landfill ban; %'s above relative to 51 states + DC).

# State MSW Recycling Goals (38 states w/goals)

| | | | | |
|---|---|---|---|---|
| 70% | MA (2005) | RI (None*) | | |
| 65% | NJ (2000*) | | | |
| 55% | ME (2003) | | | |
| 50% | CA (2000*)<br>MN (1996)<br>OH (2005)<br>WA (1995) | HI (2000)<br>NE (2002)<br>OR (2009*)<br>WV (2010) | IN (2001)<br>NM (2000)<br>SD (2001) | IA (2000)<br>NY (1997)<br>VT (2005) |
| 45% | DC (2000*) | | | |
| 40% | CT (2000*)<br>NC (2001) | MD (2005)<br>ND (2000) | MO (1998)<br>TX (1994) | NH (2000) |
| 35% | PA (2003) | SC (2005*) | | |
| 30% | DE (None) | FL (1994*) | KY (2010) | |
| 25% | AL (None)<br>NV (None) | LA (1992)<br>TN (2003*) | MI (2005)<br>VA (2000*) | MS (1996) |

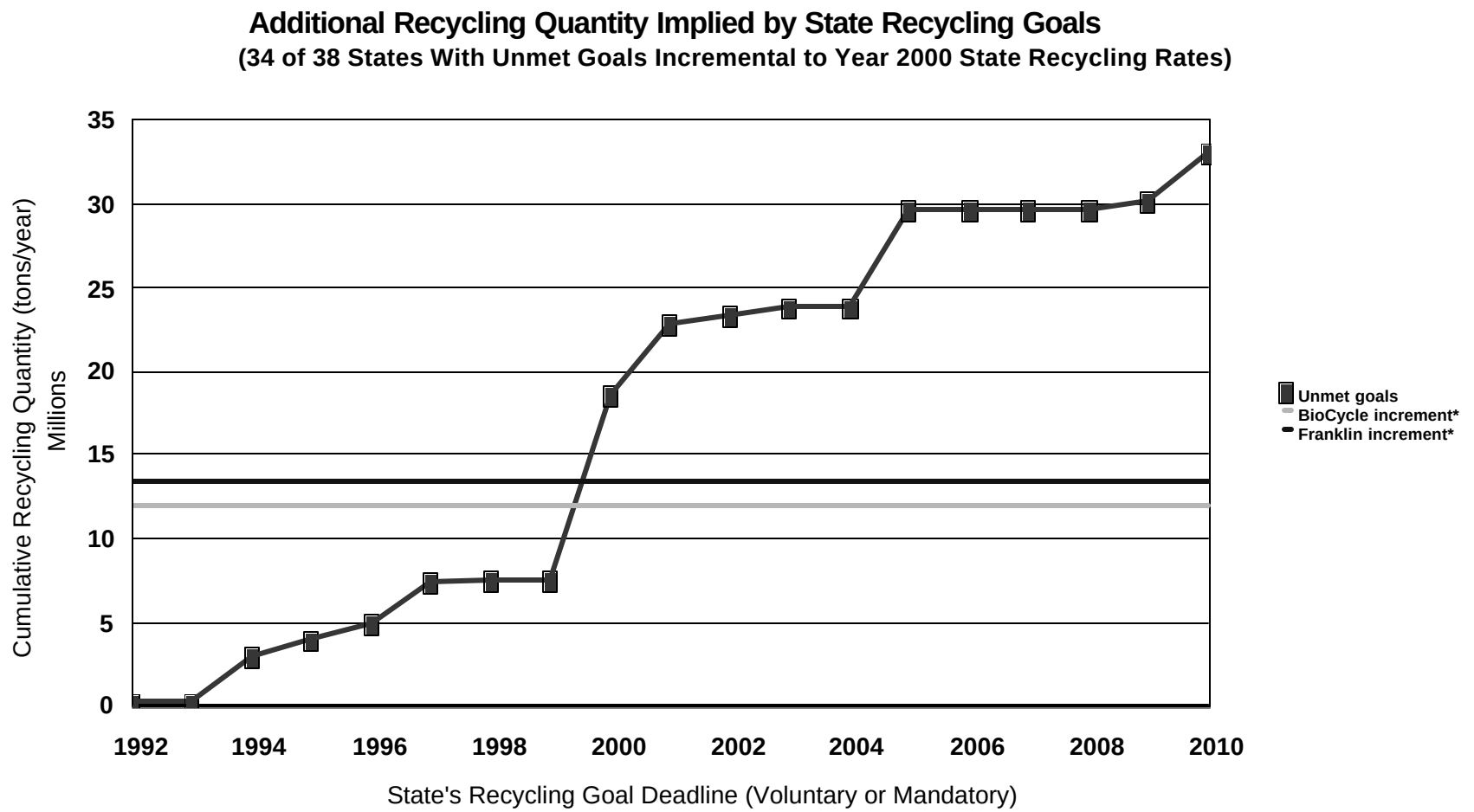
Source: BioCycle magazine, Dec 2001, Table 14, p.54 (data represent year 2000 state recycling policies).
Year in parenthesis indicates goal deadline. * Indicates mandatory goal (10 of 38 states with goals).

# Summary of State MSW Recycling Goals




Source: BioCycle magazine, Dec 2001, Table 14, page 54.

# Unmet State MSW Recycling Rate Goals




Source: Based on state MSW recycling goals from BioCycle magazine, Dec 2001, Table 14, p.54, benchmarked to year 2000 actual recycling rate & recycled waste quantity (tons).
* Incremental annual MSW quantity needed to increase national average from 30% (2000) to 35%.

# Regional Summary of <35% Recycling Rate States

| EPA Region | Nr.states | Nr.<35% | %lagging |
|---|---|---|---|
| **I (Boston)** | **6** | **4** | **67%** |
| II (NYC) | 4 | 0 | 0% |
| III (Phil.) | 6 | 3 | 50% |
| **IV (Atlanta)** | **8** | **7** | **88%** |
| V (Chicago) | 6 | 3 | 50% |
| VI (Dallas) | 5 | 3 | 60% |
| VII (Kansas C.) | 4 | 2 | 50% |
| **VIII (Denver)** | **6** | **4** | **67%** |
| IX (San Fran.) | 6 | 2 | 33% |
| X (Seattle) | 4 | 1 | 25% |
| Totals = | 55 | 29* | 53% to 64%* |

* Based on BioCycle 2000 recycling rate data for 45 states.

# 2A.2
# City MSW Recycling Rates

# MSW Recycling Rates for 25 Most Populous US Municipalities (2001/2002)

| | R+C | R | C | | R+C | R | C |
|---|---|---|---|---|---|---|---|
| 1. San Francisco | 48.0% | 38.0% | 56.0% | 14. Phoenix | NA | 21.0% | NA |
| 2. Chicago | NA | 44.3% | NA | 15. Wash DC | NA | 18.2% | NA |
| 3. San Diego | 44.0% | NA | NA | 16. Columbus | NA | 13.0% | NA |
| 4. San Jose | 42.0% | NA | NA | 17. Boston | NA | 13.0% | NA |
| 5. Los Angeles | NA | 39.0% | NA | 18. Indianapolis | NA | 11.8% | NA |
| 6. Philadelphia | 38.5% | 5.5% | NA | 19. San Antonio | NA | 10.1% | NA |
| 7. Seattle | 37.9% | 48.5% | 36.7% | 20. Detroit | NA | 7.2% | NA |
| 8. New York | 35.7% | 19.8% | 44.0% | 21. Nashville | 7.0% | 8.0% | NA |
| 9. Jacksonville | 33.0% | 35.0% | 43.0% | 22. Houston | NA | 7.0% | NA |
| 10. Austin | NA | 29.5% | NA | 23. Denver | NA | 6.7% | NA |
| 11. Baltimore | 28.7% | NA | NA | 24. El Paso | 2.5% | NA | NA |
| 12. Milwaukee | NA | 26.8% | NA | 25. Dallas | NA | 2.2% | NA |
| 13. Memphis | NA | 25.6% | NA | | | | |

Source: Waste News, 17 Feb 2003.
NA = not available.

R = residential recycling rate
C = commercial recycling rate

# Regional Summary of <35% Recycling Rate For 25 Most Populous Municipalities

| EPA Region | Nr.cities | Nr.<35% | %lagging |
|---|---|---|---|
| **I (Boston)** | **1** | **1** | **100%** |
| II (NYC) | 1 | 0 | 0% |
| III (Phil.) | 3 | 2 | 67% |
| **IV (Atlanta)** | **4** | **3** | **75%** |
| **V (Chicago)** | **5** | **4** | **80%** |
| **VI (Dallas)** | **4** | **4** | **100%** |
| VII (Kansas C.) | 0 | 0 | NR |
| **VIII (Denver)** | **1** | **1** | **100%** |
| IX (San Fran.) | 5 | 1 | 20% |
| X (Seattle) | 1 | 0 | 0% |
| Totals = | 25 | 16 | 64% |

# 2A.3
# Materials Recycled

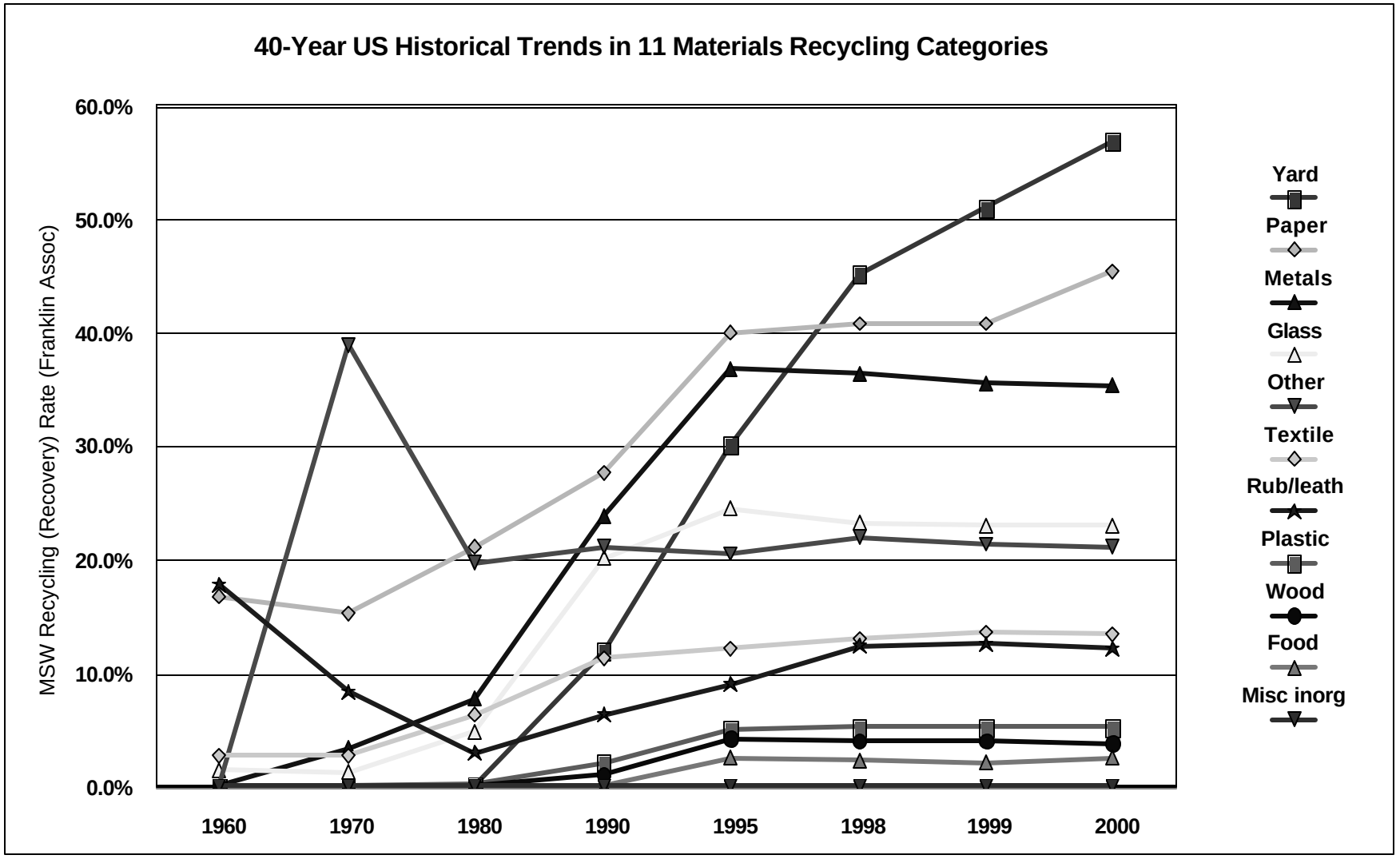
# Baseline Materials Recycled (2000)

| 2000 Generation (million tons) | |
|---|---|
| 1. Paper & paperboard | 86.7 |
| 2. Yard trimmings | 27.7 |
| 3. Food | 25.9 |
| 4. Plastics | 24.7 |
| 5. Metals | 18.0 |
| 6. Glass | 12.8 |
| 7. Wood | 12.7 |
| 8. Textiles | 9.4 |
| 9. Rubber & leather | 6.4 |
| 10. Other materials NEC | 4.0 |
| 11. Misc inorganic wastes | 3.5 |
| Total = | 231.9 |

| Recovery as % of Generation | |
|---|---|
| 1. Yard trimmings | 56.9% |
| 2. Paper & paperboard | 45.4% |
| 3. Metals | 35.4% |
| 4. Glass | 23.0% |
| 5. Other materials NEC | 21.3% |
| 6. Textiles | 13.5% |
| 7. Rubber & leather | 12.2% |
| 8. Plastics | 5.4% |
| 9. Wood | 3.8% |
| 10. Food | 2.6% |
| 11. Misc inorganic wastes | 0.05% |
| Total = | **30.1%** |

Source: Franklin Assoc. (EPA-530-R-02-001), Table ES-4, page 7.

# Historical Trends in Materials Recycling Categories



# 2A.4
# Recent Policy Decisions and Future Policy Options for Affecting MSW Recycling Rates

# Examples of Recent Developments Which May Increase the Near-Future MSW Recycling Rate

Recycling (Materials) Supply Factors:

- In 2002, the Metropolitan Gov't of Nashville & Davidson County implemented a single-stream curbside recycling program to raise the city's 8% recycling rate to 25% by 2004.
- In 2003, Seattle Public Utilities launched a program to increase multi-family recycling from 22% (2001) to 37% in 2008.
- NY enacted a law May 2003 to clean-up scrap tires & encourage markets for recycling, and created a fee ($2.5 per new tire sold) to fund tire recycling.

Recycling (Materials) Demand Factors:

- In 2003, Waste Management Inc formed the new recycling organization "Recycle America Alliance" (http://www.recycleamericaalliance.com), to combine assets and operations with other domestic recycling processors and marketers; WMI's first partner is The Peltz Group (Milwaukee WI), the largest privately owned US recycler.
- The US paper industry (AF&PA) decided in 2002 to boost the recovered fiber recycling rate from 48% (current) to 55% in 2012, by collecting more used paper from offices and schools.
- Starting in 1999, Albertson's US grocery chain (2,300 stores) is pushing its suppliers to use non-waxcoated boxes to boost box recycling beyond 85%.
- In 2003 the California State Senate Appropriations Committee approved a bill that would require electronics manufacturers to develop and finance a free and convenient system to recycle end-of-life electronics. As of May 2003, 26 states introduced 52 bills on electronics recycling, according to State Recycling Laws Update from Raymond Communications, Inc. (http://www.raymond.com/state/).
- In June 2003 the New York State Assembly passed a bill (147-0) requiring the recycling of wireless phones.
- Waste Management Inc. decided in 2003 to open a second plastic bottle recycling facility in Chicago in 2004 that will handle 100 million pounds of plastic a year, duplicating a plant in North Carolina that started operating early last year.

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- China's demand for US exports of recovered paper fiber projected to grow from 1 million (1995) to 6 million tons (2003)

# Examples of Recent Developments Which May Decrease the Near-Future National MSW Recycling Rate

Recycling (Materials) Supply Factors:

- The year 2002 "Green Gauge" survey reported that the biggest drop in American's participation in environmentally-friendly activities is for recycling: 45% regularly return bottles to a store or recycling center, and 36% take part in a curbside recycling program, down 6 and 9 points respectively from 2001.

- Iowa state legislature voted in 2003 to remove a landfill ban on yard waste (http://www.wastenews.com/headlines2.html?id=1054241503); but on 12 June 2003, Iowa Gov. Tom Vilsak vetoed this legislation. "Bans on disposal of yard trimmings in landfills have made it possible to essentially double the overall diversion rate and are absolutely vital to achieving America´s recycling goals, which is why 21 other states have also enacted laws banning disposal of yard trimmings," said Neil Seldman, president of the Institute for Local Self-Reliance.

- Since the mid-1980s, the popularity of cell phones has soared from 340,000 people in the US owning cell phones, to 130 million cell phones — complete with batteries and chargers — will be pitched each year by 2005, adding an annual 65,000 tons of garbage to the nation's solid waste stream, mostly for landfilling and incineration.

- The aluminum can US recycling rate has dropped for the 5th straight year from 67% (1997) to 53% (2002).

Recycling (Materials) Demand Factors:

- MA launched a recycling center at Univ of MA in 1995 to stimulate manufacturers' use of recycled materials, but is closing it June 2003 due to lack of continued funding.

# Policy Options for Stimulating Recycling Implied From Baseline Data

- Target attention/assistance to major municipalities:
  - Up to 16 of 25 most populous cities <35% goal (R+C)

- Target attention/assistance to states:
  - Up to 29 of 45 states <35% goal
  - At least 20 states <53% state population coverage national average

- Target attention/assistance to EPA Regions:
  - Regions I, IV, VIII >65% average lag for states under jurisdiction
  - Regions I, IV, V, VI, VIII >65% average lag for top-25 municipalities within jurisdiction

- Target materials recycling categories:
  - 8 of 11 materials <35% goal
  - Metals, glass, & rubber/leather recycling rates declining since 1998
  - Plastics, wood, and food <5% recycling rates.

- Facilitate/expand municipal & state recycling initiatives:
  - Promote initiatives/programs in other jurisdictions (e.g. single-stream pickup, schools, multi-family apts, grocery stores, electronics)
  - Implement national guidance or national RCRA legislation (e.g. yard waste landfill bans only in 23 states as of 1997).

# 2B. MSW Recycling Infrastructure

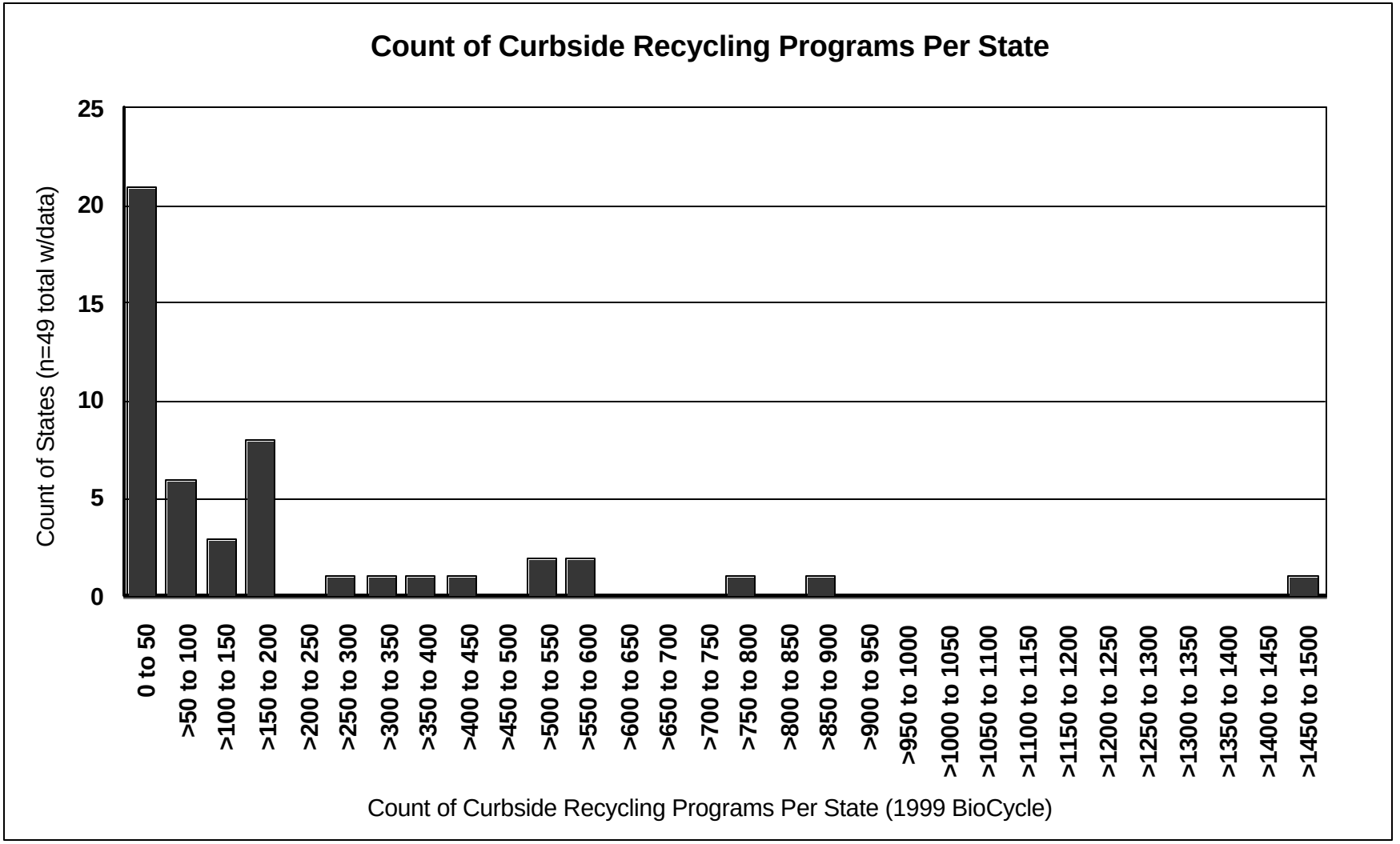
2B.1 Statewide Population Coverage
2B.2 Urban & Rural Penetration
2B.3 Comparison of Recycling Rates & Infrastructure

# Overview of MSW Recycling Infrastructure

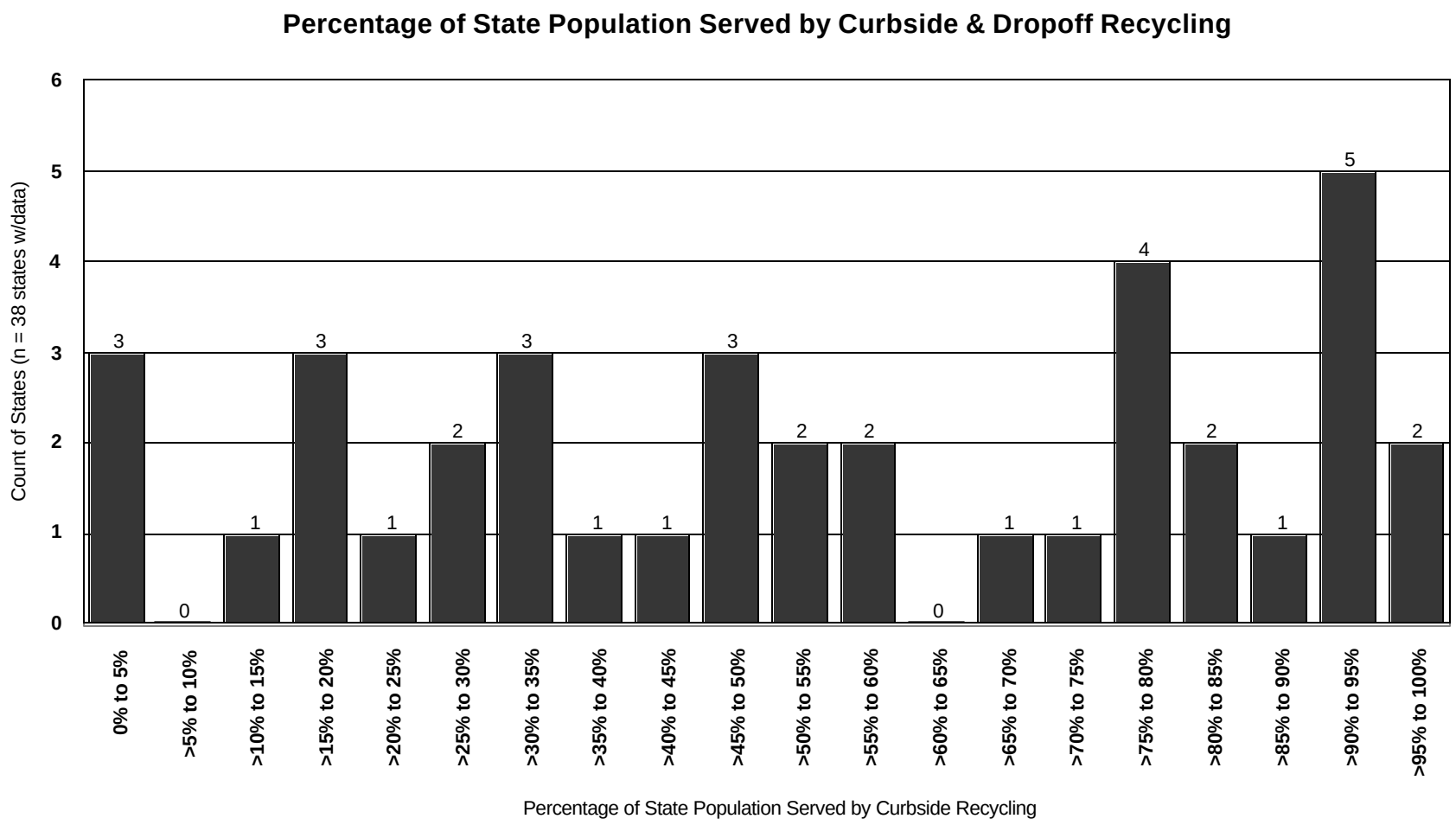
- In 1997 51% of US population had access to curbside recycling programs.
- In 2000 there were 9,250 curbside recycling programs (represents a 39% maximum coverage for 23,435 total US municipalities; aka Census "places").
- In 1997 there were 12,700 drop-off centers for recyclables, compared to 23,435 total 1990 municipalities in the US (represents a 54% maximum coverage).
- National ratio of communities (and tonnage) with curbside:to:drop-off recycling = 90%:to:10%
- In 1997 there were 1,540 solid waste collection/hauling establishments selling recyclable materials ($414 million receipts; NAICS code=562111, NAICS RL code=4450).
- Waste/scrap shipped an average of 164 miles in 1997.
- In 1997 there were 765 establishments involved in sorting MSW recyclable materials ($1.3 billion receipts, 10,900 employees; NAICS=562920).
- 30 states reported annual state government budgets for recycling (including composting) totaling $173 million in 2000 (PA leads at $6.17/year per resident).
- Of the 25 most populous cities, San Diego leads municipal government recycling budgets at $15.04/year per resident.
- 38 states have recycling goals: 26 states have set state-wide recycling goals >35% for achievement by 1994 (TX) to 2010 (MA & WV); 12 states set recycling goals <35%.

# 2B.1
# MSW Recycling Infrastructure:
# Statewide Population Coverage (2000)

# Number of Curbside Recycling Programs Per State



# MSW Recycling Services: State Population Coverage




Source: OSW estimate based on curbside recycing population coverage from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented with additional 10% dropoff assumption.

# State Population Coverage Statistics (prior graph)

1. CT 100%
2. NJ 99.0%
3. RI 94.3%
4. CA 92.0%
5. NY 90.8%
6. WA 90.2%
7. NV 90.2%
8. OR 85.5%
9. MA 84.6%
10. MN 83.6%
11. PA 79.6%
12. IN 76.2%
13. MD 75.5%
14. IA 75.3%
15. IL 72.0%
16. WI 65.7%
17. VT 59.3%
18. FL 59.1%
19. AZ 52.6%
20. KS 50.5%
21. NC 48.3%
22. SC 46.4%
23. NH 45.9%
24. ME 42.4%
25. HI 36.7%
26. OK 34.0%
27. MI 33.0%
28. NE 32.5%
29. AL 27.5%
30. TX 26.6%
31. NM 24.4%
32. VA 18.0%
33. ND 17.3%
34. KY 16.2%
35. MS 12.7%
36. WY 4.5%
37. DE <1%
38. AK 0%

Source: OSW estimate based on curbside recycling population served data from BioCycle magazine (Dec 2001, Table 6, p. 47), supplemented with additional 10% assumed dropoff recycling population served (per 90:to:10 overall national ratio); 13 states do not have data on population coverage.

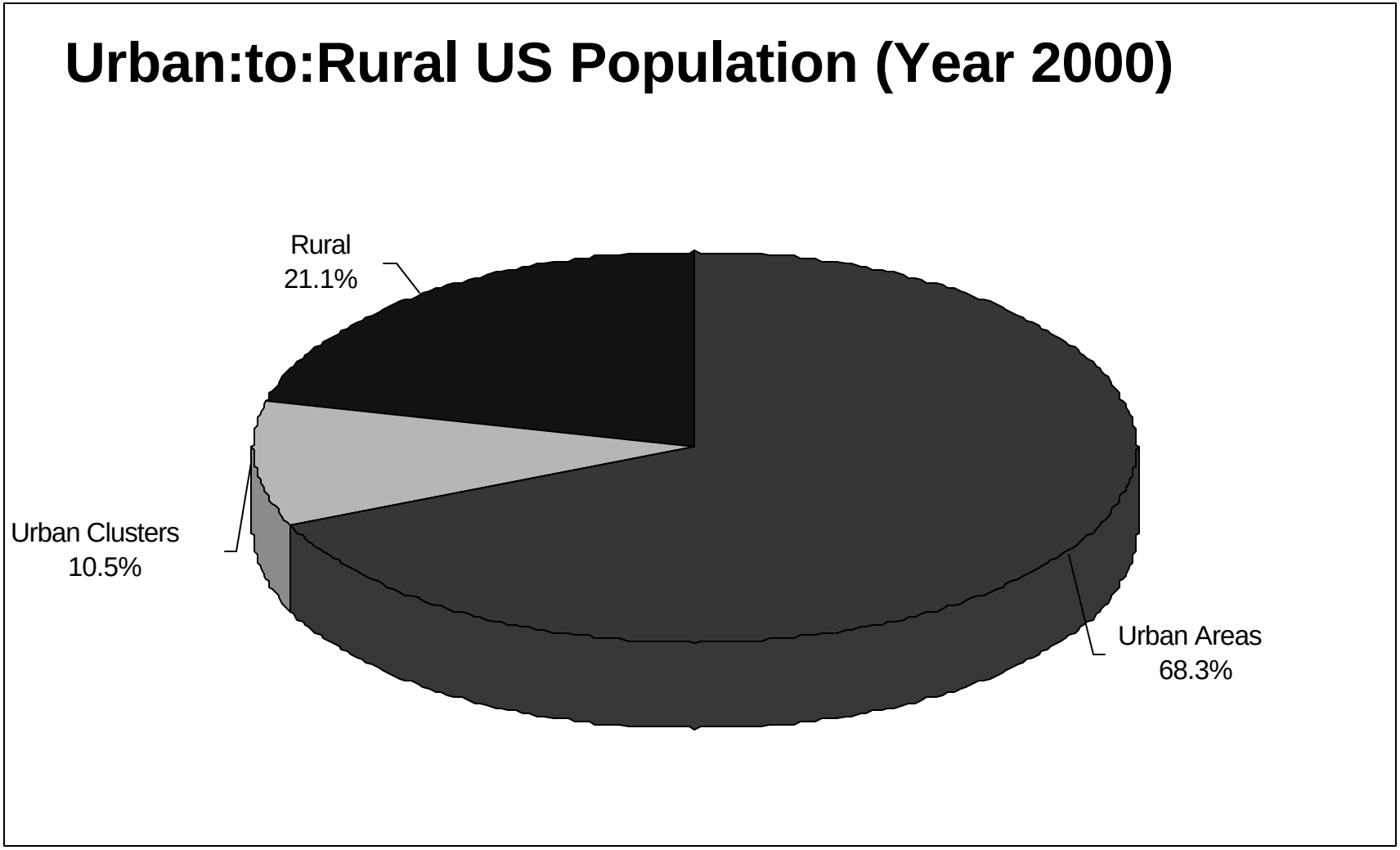
# As of 2000, 13 States Lack Knowledge (Data) About Fraction of Population Served by Recycling Programs

- Arkansas (na)
- Colorado (n/a)
- DC (1)
- Georgia (459)
- Idaho (20)
- Louisiana (25)
- Missouri (177)
- Montana (na)
- Ohio (232)
- South Dakota (na)
- Tennessee (na)
- Utah (7)
- West Virginia (51)

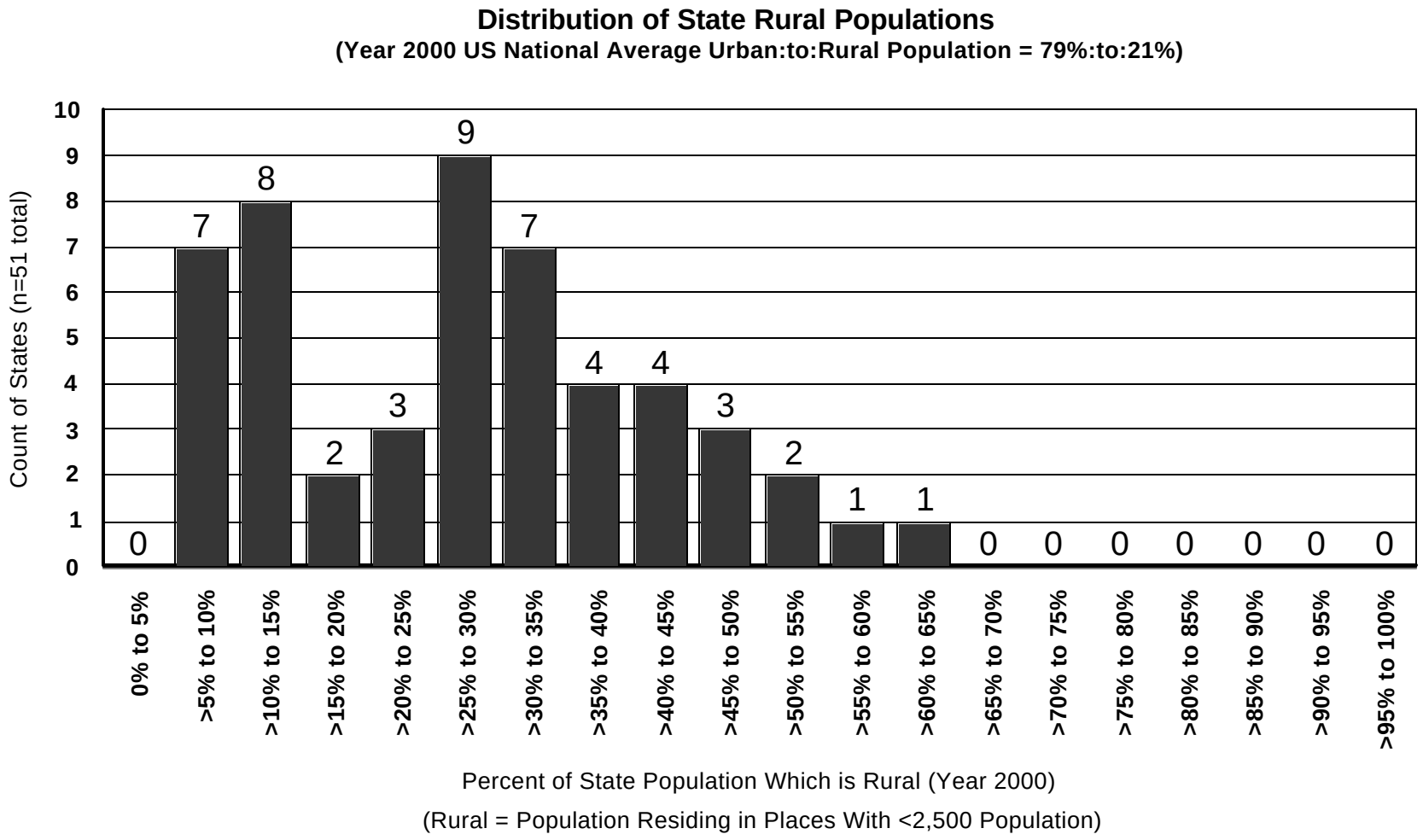
Numbers in parentheses indicate count of state curbside recycling programs (year 2000).
Source: BioCycle magazine, Dec 2001, Table 6, p.47
Na = data not available from state in 2001 survey.

# 2B.2
# MSW Recycling Infrastructure: Urban & Rural Penetration (2000)

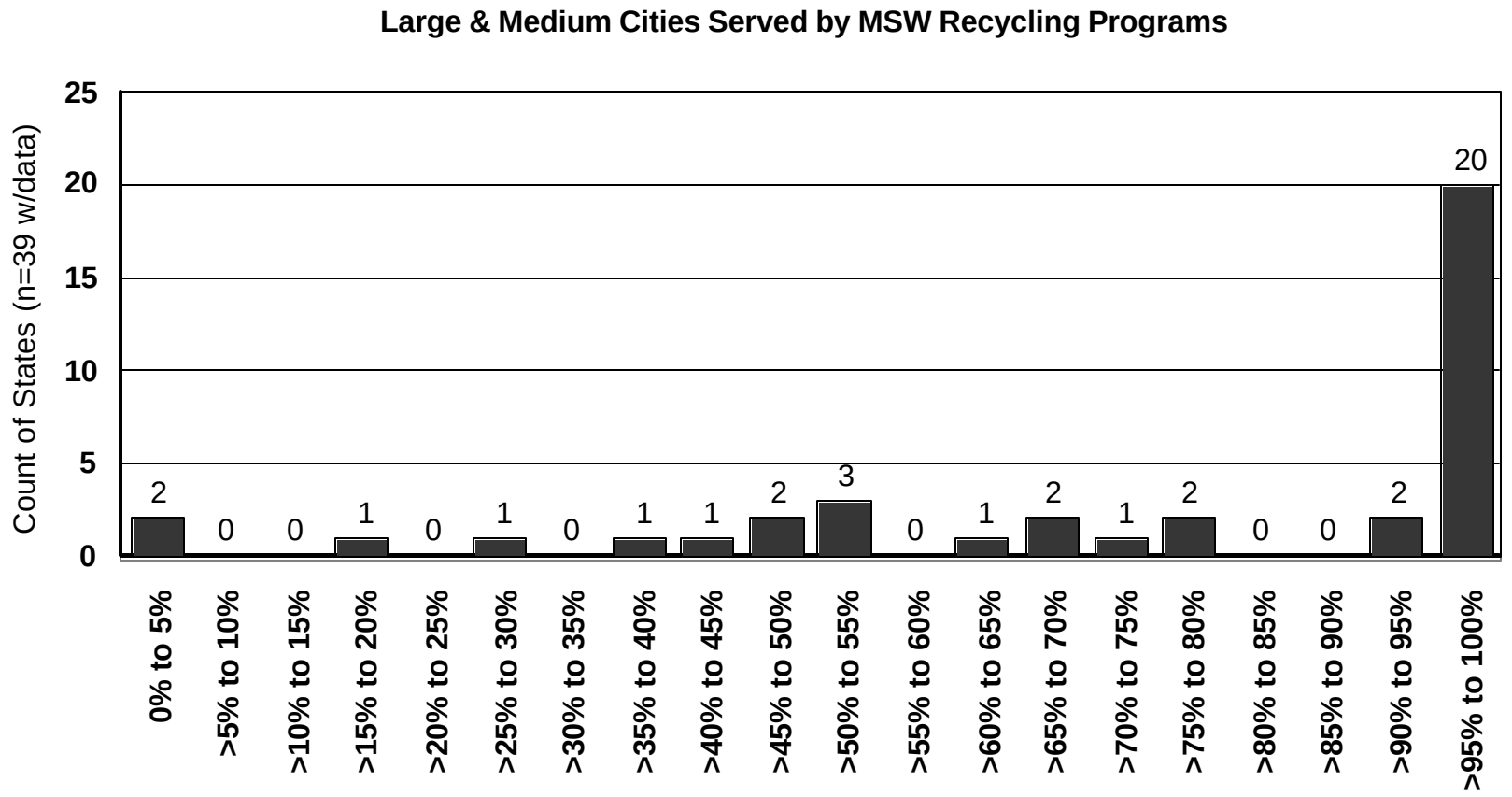
# Urban:to:Rural US Population (Total = 281.4 million year 2000)



# 21% Rural Population: Economically-Beneficial MSW Recycling May Require Population Density to Avoid High Collection Costs

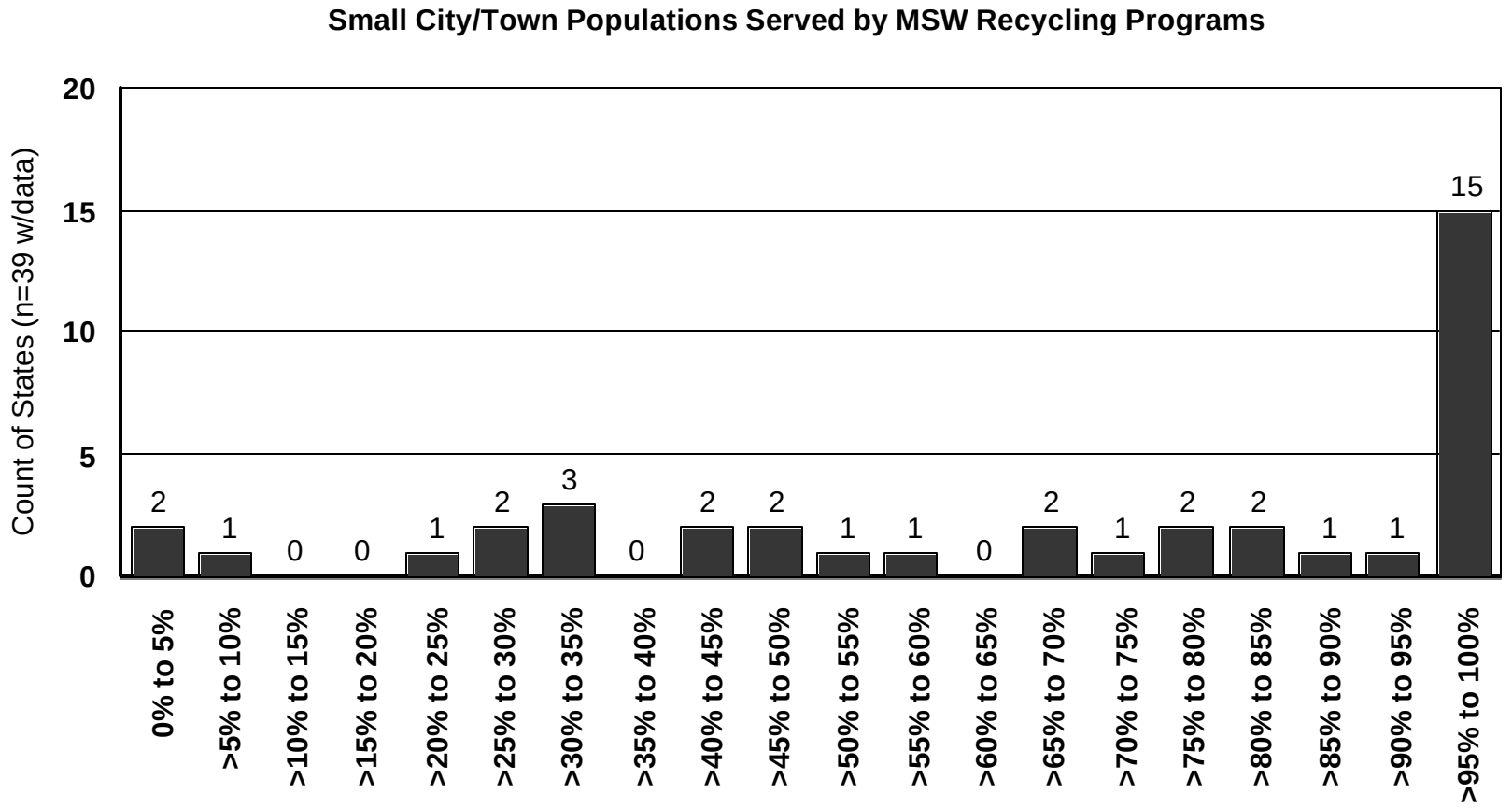


# Large & Medium Cities ("Urban Areas" >50,000 Population) in State Served by MSW Recycling Programs (2000)



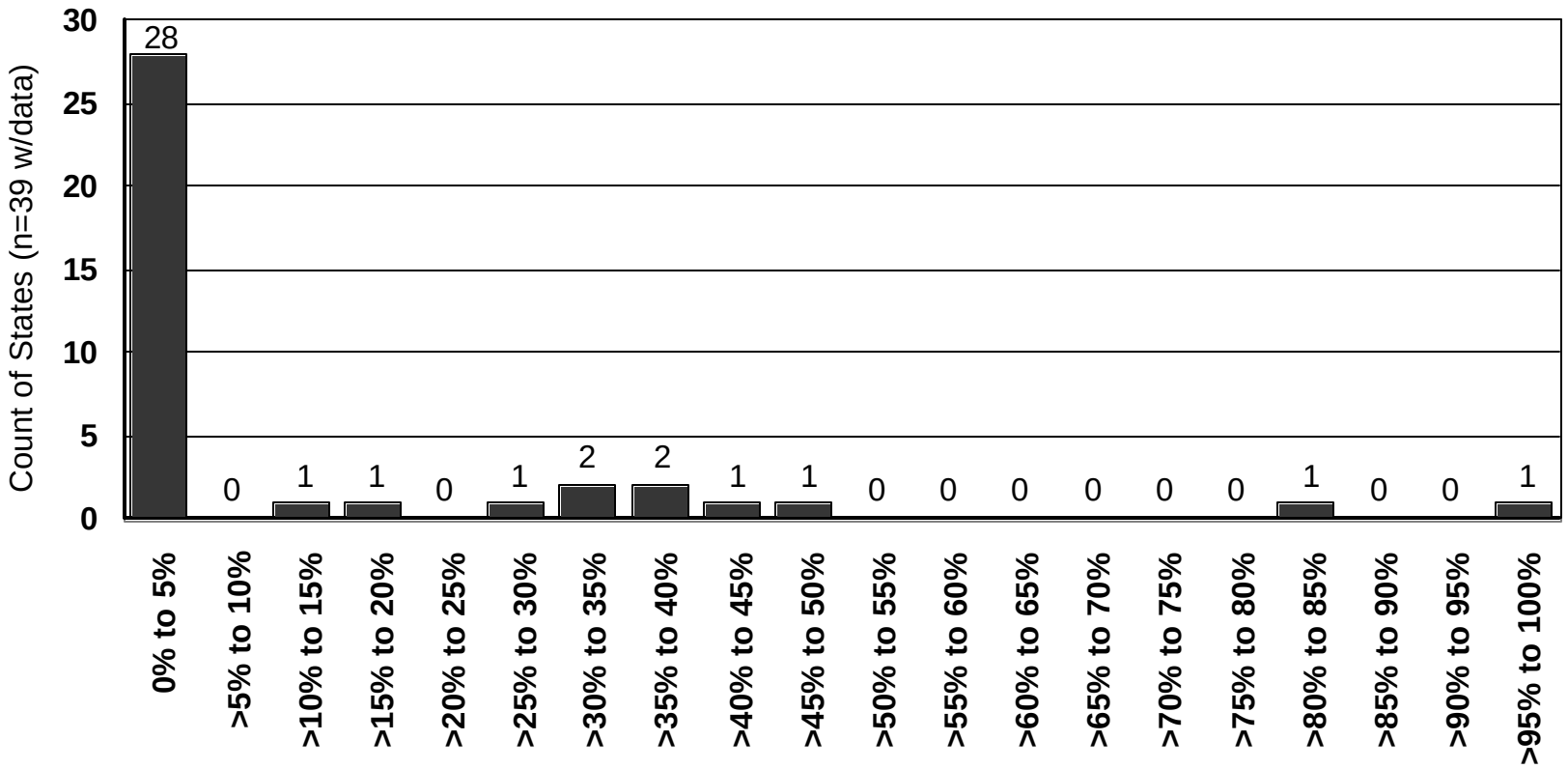

Source: Based on curbside population served from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented by up to 10% dropoff estimate.

# Small Cities / Towns ("Urban Clusters" 2,500 to 50,000 Population) Served in State by MSW Recycling Programs (2000)




Source: Based on curbside population served from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented by up to 10% dropoff estimate.

# Rural Areas (<2,500 Population) Served in State by MSW Recycling Programs (2000)




Source: Based on curbside population served from BioCycle magazine, Dec 2001, Table 6, p.47, supplemented by up to 10% dropoff estimate.

# 2B.3

# Exploratory Statistical Comparisons of Statewide & City MSW Recycling Rates & Recycling Infrastructure (see graphs in Appendices)

The following are the apparent strongest statistical (X-Y plot) associations exhibited for possible drivers behind MSW recycling rates & costs (negative sign indicates inverse association; % is trendline fit to data displayed in Appendices)

- State Recycling Infrastructure Comparisons (based on 1 data set):
  - 51%: Recycling rate compared to state count of incorporated places divided by state count of recycling programs (-)
  - 35% Recycling rate compared to state recycling budget per capita (+)
  - 35%: Recycling rate compared to state land area divided by state count of recycling programs (-)
  - 34%: Recycling rate compared to state population divided by state count recycling programs (-)

- Municipality Recycling Infrastructure Comparisons (based on 2 data sets):
  - 40%: Recycling cost ($/ton) compared to annual quantity MSW recycled by municipality (-)
  - 33%: Recycling cost ($/ton) compared to municipal population (+)
  - 21%: Recycling rate compared to municipal population density (per square mile) (+)
  - 19%: Recycling cost (&/ton) compared to municipal population density (-)
  - 19%: Recycling cost ($/ton) compared to municipal recycling rate (-)
  - 17%: Recycling rate compared to municipal gov't budget per-capita spending on recycling programs (+)
  - 15%: Recycling rate compared to percentage of municipal budget spent on recycling programs (+)

# 2C. Benefit-Cost Analysis of 35% Goal

2C.1 Recycling Costs
2C.2 Recycling Benefits
2C.3 Recycling Benefit-Cost Ratio (BCR)
2C.4 Recycling Impact on National Employment

# 2C.1
# MSW Recycling Costs

# MSW Recycling Cost Dataset (Drop-off Programs in 14 Cities, 1995)

**DROP-OFF RECYCLING UNIT COSTS**

Source: Table II-5, EPA-600-R-95-109, July 1995 (1993$)

* Total cost = annualized capital cost + O&M cost + education/admin cost

| Case study | City | State | 1990? population | Public or private | Annual tons collected | Total cost* net of revenues ($/ton) | O&M ($/ton) | O&M as % total cost | overhead ($/ton) | Recycled materials revenues ($/ton) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Santa Monica | CA | 86,905 | public | 3,214.2 | $73.83 | $50.57 | 68.5% | $23.26 | $0 |
| 2 | Southeast | CO | 111,727 | private | 1,324.0 | $71.73 | $68.71 | 95.8% | $3.02 | $36.00 |
| 3 | Largo | FL | 38,400 | public | 2,040.0 | $81.43 | $23.16 | 28.4% | $58.27 | $17.16 |
| 4 | Tampa | FL | 229,712 | public | 3,272.7 | $95.24 | $59.03 | 62.0% | $36.21 | $0 |
| 5 | Blue Ash | OH | 13,629 | private | 701.0 | $51.36 | $25.68 | 50.0% | $25.68 | $0 |
| 6 | W.Greenwich | RI | 2,749 | private | 156.0 | $86.28 | $73.46 | 85.1% | $12.82 | $0 |
| 7 | Falmouth | ME | 7,610 | private | 338.0 | $87.22 | $67.49 | 77.4% | $19.73 | $0 |
| 8 | Freeport | ME | 7,043 | private | 320.0 | $155.30 | $91.21 | 58.7% | $64.09 | $23.99 |
| 9 | Queen Village | PA | 9,443 | public | 250.0 | $60.00 | $60.00 | 100.0% | $0 | $0 |
| 10 | Cedar Park | PA | 13,461 | public | 202.0 | $60.00 | $60.00 | 100.0% | $0 | $0 |
| 11 | Chesterfield | VA | 225,100 | private | 3,081.8 | $41.35 | $40.57 | 98.1% | $0.78 | $4.94 |
| 12 | Petersburg | VA | 38,400 | private | 357.2 | $36.59 | $35.50 | 97.0% | $1.09 | $4.22 |
| 13 | Henrico | VA | 230,000 | private | 3,402.8 | $41.36 | $33.95 | 82.1% | $7.40 | $7.71 |
| 14 | Norfolk | VA | 261,229 | public | 982.8 | $86.00 | $80.75 | 93.9% | $5.25 | $4.13 |
| | | Min = | 2,749 | | | $36.59 | $23.16 | 28.4% | $0.00 | $4.13 |
| | | Max = | 261,229 | | | $155.30 | $91.21 | 100.0% | $64.09 | $36.00 |
| | | Mean = | 91,101 | | | $73.41 | $55.01 | 78.4% | $18.40 | $14.02 |
| | | Median = | 38,400 | | | $72.78 | $59.52 | 83.6% | $10.11 | $7.71 |
| | | | | | Std.dev= | $30.41 | $20.85 | 22.1% | $21.34 | $11.08 |
| | | | | | Tons-wtd avg = | $67.79 | $47.61 | 74.1% | $20.18 | |
| | | | | | Skewness = | 1.24 | | | | |
| | | | | | -68% conf. = | $43.00 | | | | |
| | | | | | +68% conf. = | $103.82 | | | | |
| | | | | | Updated to year 2002$: | | | | | |
| | | | | | Min = | $44.25 | | | | $4.99 |
| | | | | | Max = | $187.80 | | | | $43.53 |
| | | | | | Mean = | $88.77 | | | | $16.96 |
| | | | | | Median = | $88.01 | | | | $9.32 |
| | | | | | Std.dev= | $36.77 | | | | $13.40 |
| | | | | | Tons-wtd avg = | $81.98 | | | | |
| | | | | | Skewness = | $1.50 | | | | |
| | | | | | -68% conf. = | $52.00 | | | | |
| | | | | | +68% conf. = | $125.54 | | | | |

# MSW Recycling Cost Dataset (Curbside) Compared to Garbage Collection Costs

## CURBSIDE COLLECTION RECYCLING UNIT COSTS

Source: Table 3, page 26, EPA-530-R-01-018, Nov 2001 (2000$)

Unit costs based on "full cost accouting" method, including transportation + fringe

| | 2001 Nat'l | | | | Skewed interval method | |
|---|---|---|---|---|---|---|
| | Proportion | Min | Mean | Max | -68% conf. | +68% conf. |
| Multi-family | 24% | $62 | $177 | $622 | $120 | $400 |
| Single-family | 76% | $11 | $127 | $420 | $69 | $274 |
| | Weighted = | $23 | $139 | $468 | $81 | $304 |
| Updated (2002$) = | | | $142 | | $83 | $311 |

Price decline for single-family curbside recycling:

| | Year | $/ton |
|---|---|---|
| | 1993 | $170 |
| | 2000 | $127 |
| Average annual rate = | | -4.08% |

## REFUSE (GARBAGE) COLLECTION UNIT COSTS

Source: Table 3, page 26, EPA-530-R-01-018, Nov 2001 (2000$)

| | 2001 Nat'l | | | | Skewed interval method | |
|---|---|---|---|---|---|---|
| | Proportion | Min | Mean | Max | -68% conf. | +68% conf. |
| Multi-family | 24% | $16 | $63 | $171 | $40 | $117 |
| Single-family | 76% | $16 | $69 | $286 | $43 | $178 |
| | Weighted = | $16 | $68 | $259 | $42 | $163 |
| Updated (2002$) = | | | $69 | | $43 | $167 |

ENR Building cost index update factor (2002/2000) = 1.024

# MSW Recycling Direct Cost Compared to Two Cost Offsets

Direct costs for operating recycling programs usually exceed cost offsets:

| Cost Offset Example #1(40 cities, 2002$): | -1SD | Mean | +1SD |
|---|---|---|---|
| ▪ Recycling program net cost* ($/ton) | $83 | $142 | $311 |
| ▪ Avoided garbage collection cost offset* ($/ton): | $43 | $69 | $167 |
| ▪ Avoided garbage disposal cost offset** ($/ton): | $30 | $36 | $58 |
| Total cost offset ($/ton) = | $73 | $105 | $225 |
| Recycling net cost w/offset ($/ton) = | $10 | $37 | $86 |
| Offset as % of recycling cost = | 88% | 74% | 72% |

| Cost Offset Example #2 (30 cities, 2002$): | | | |
|---|---|---|---|
| Recycling program total cost*** ($/ton) | $4 | $64 | $124 |
| ▪ Offset value of recyclable materials*** ($/ton): | <$0.1 | $10 | $44 |
| Recycling net cost w/offset ($/ton) = | $3 | $54 | $80 |
| Offset as percentage of recycling cost = | <1% | 16% | 35% |

Data Sources & Notes (SD = standard deviation):

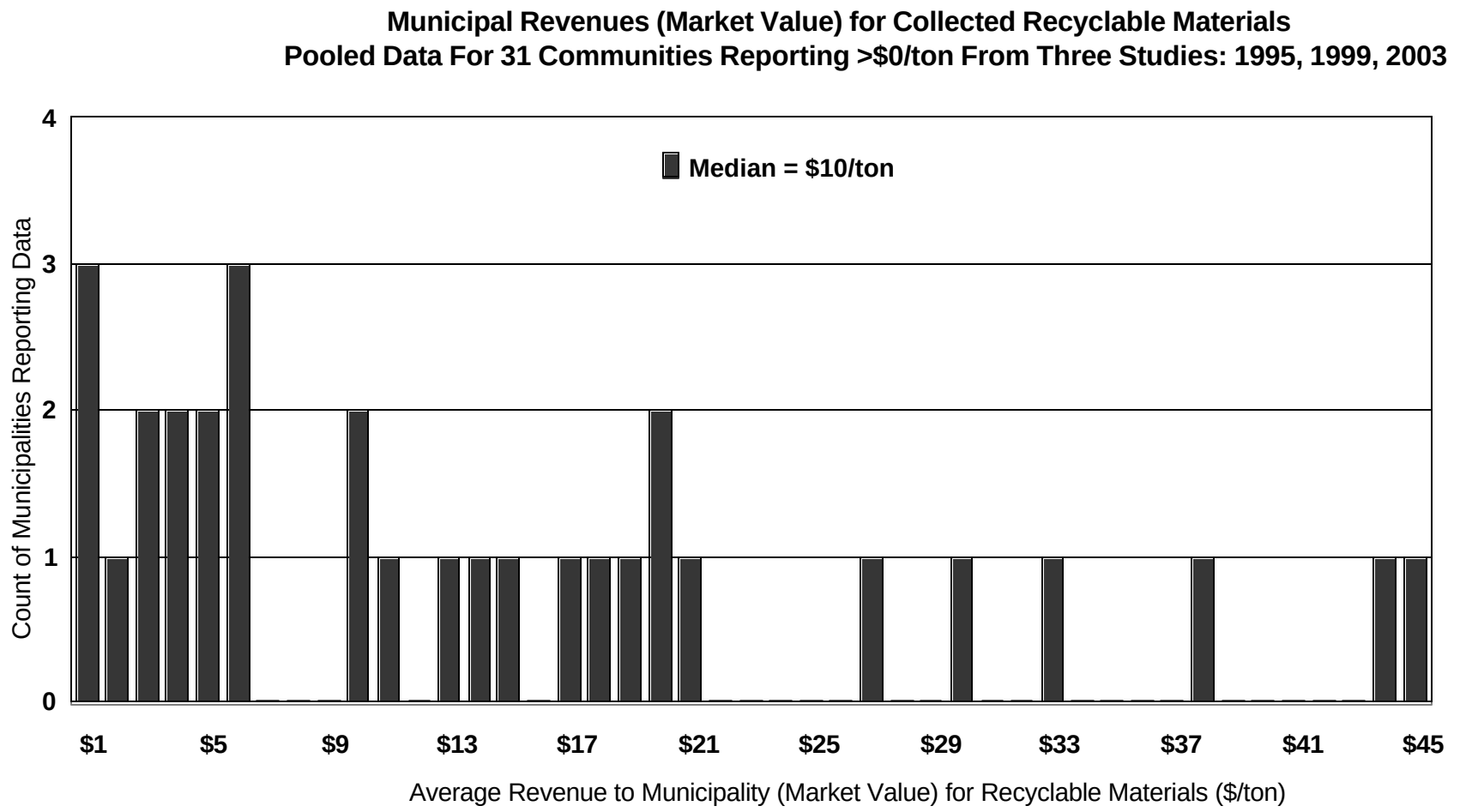
* EPA-530-R-01-018, Nov 2001, Table 3, p.26; based on data ranges for 40 communities ranging from 28,000 to 8.0 million population (median = 70,000); net cost = cost to local government, minus any recycled material revenues.

** Year 2002 landfill tipping fees from http://wasteinfo.com/data.htm (LB = landfills; ML= wtd avg if 55.3% landfill + 14.5% combust; UB= combust).

*** Based on pooled data points for 31 communities ranging from 1,900 to 6.0 million population, from three reports (EPA-600-R-95-109 July 1995, EPA-530-R-99-013 June 1999, & Waste News magazine17 Feb 2003) for curbside and dropoff recycling programs; normalized by OSW to 2002$ (Mid = median).

- Collection transportation (hauling) reportedly constitutes 39% to 62% of total annualized cost.
- On average, capital investment reportedly represents 22% and annual O&M 78%, of total annualized cost.
- Single-family household curbside recycling costs have declined an average of 4.1% per year between 1993 & 2000.

# Market Value of Pre-Processed Recyclable Materials Collected ($/ton)




Sources: (a) EPA-600-R-95-109 July 1995; (b) EPA-530-R-99-013 June 1999; (c) Waste News magazine 17 Feb 2003; all data normalized to 2002$

# US Market Values for Pre-Processed Recyclable Materials ($/ton, July 2003)

| Type of Recyclable Material | Low | Avg | High |
|---|---|---|---|
| ■ Metals | | | |
| ❑ Steel (cans, white goods) | $10* | $33* | $51* |
| ❑ Aluminum | $25 | $31 | $40 |
| ■ Glass | | | |
| ❑ Flint | $15 | $24 | $33 |
| ❑ Amber | $5 | $16 | $30 |
| ❑ Green | ($20) | ($2) | $5 |
| ■ Plastics | | | |
| ❑ PET | $10 | $12 | $18 |
| ❑ Natural HDPE | $15 | $17 | $17 |
| ❑ Colored HDPE | $8 | $12 | $13 |
| ■ Paper (baled mixed) | $31** | $35 | $46** |

_____

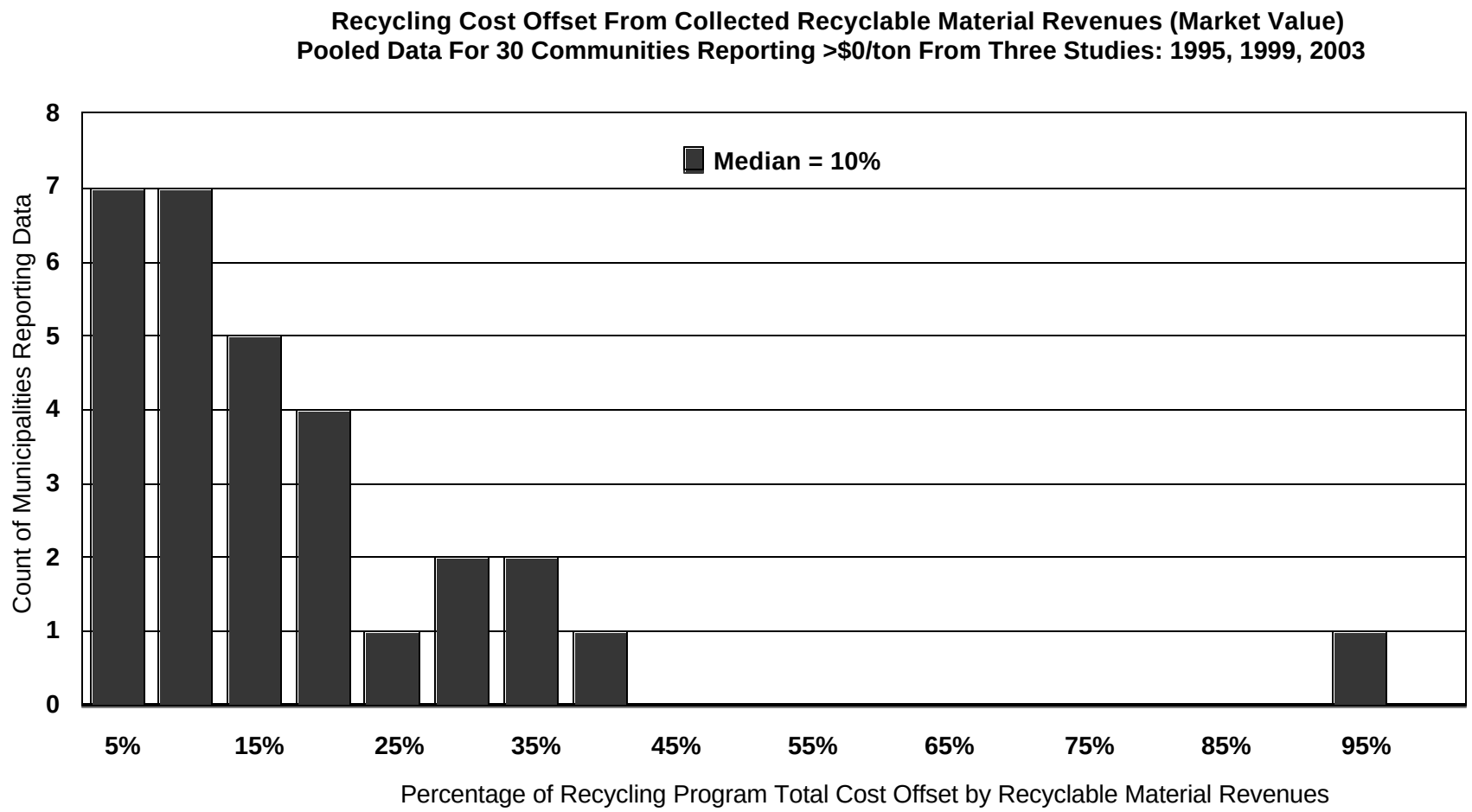
Source: Based on delivered price data for five US cities (New York, Atlanta, Chicago, Houston, Los Angeles) reported in Waste News magazine, 07 & 21 July 2003.

* In comparison, one of the US largest metal recyclers (Metal Management Inc, Chicago) reported $142/ton average selling price for post-processed recycled ferrous metals in first quarter of 2003 (Waste News, 12 Aug 2003). Other metal prices (scrap & virgin) are available at http://www.metalprices.com

**Low and high paper prices represent range over first seven months in 2003.

Parenthesis indicate negative price (i.e. payment to recovery facility to take recyclable materials).

# Recycling Cost Offset From Recyclable Material Revenues




Sources: (a) EPA-600-R-95-109 July 1995; (b) EPA-530-R-99-013 June 1999; (c) Waste News magazine 17 Feb 2003.

# National Annual Direct Cost of Achieving 35% Goal

- Incremental Tonnage: **12.0 million tons/year** additional recycling needed to achieve 35% (average of Franklin & BioCycle increments calculated relative to 2000 baseline).

- Unit Cost for Recycling (30 cities; 2002%):
  - Recycling collection: data sample* mix of curbside & dropoff programs ranges from $4 LB to $124 UB per ton (median = **$64/ton)** Note: this excludes societal cost for (a) household waste sorting time, (b) household container/space cost, & (c) household travel costs to recycling drop-off locations.
  - Recycling processing: Cost for processing collected recyclable material at an MRF (material recovery facility) = $14/ton LB to $95/ton UB (median = **$55/ton**); based on data for four cities from EPA-530-R-99-013.
  - Total cost (collection + processing) = $35/ton LB to $162/ton UB (median = **$98/ton**).

- National Incremental Cost: Applied to the 12.0 million tons/year incremental recycling to achieve 35%, produces a national incremental cost estimate of ($millions/year):

| Estimate range** | $/ton | Capital (22%) | O&M (78%) | Total |
|---|---|---|---|---|
| Lower-bound: | $35 | $92 | $328 | $420 |
| Most-likely: | $98 | $259 | $917 | **$1,176** |
| Upper-bound: | $162 | $428 | $1,516 | $1,944 |

LB = lower-bound = (mean or median – 1 SD); UB = upper-bound = (mean or median + 1SD).

* Based on pooled data points for 30 communities ranging from 1,900 to 6.0 million population, from three reports (EPA-600-R-95-109 July 1995, EPA-530-R-99-013 June 1999, & Waste News magazine17 Feb 2003) for curbside and dropoff recycling programs; normalized by OSW to 2002$ (Mid = median).

** Estimation range (lower-bound and upper-bound) represents +/-1 standard deviation about most-likely value (i.e. 68% confidence interval).

# 2C.2
# MSW Recycling Benefits

# National Annual Recycling Benefits Category #1

The national economic cost (i.e. societal cost) for MSW recycling may be formulated as the direct annual cost to municipalities (capital investment costs + annual O&M costs) for operating recycling programs, plus the annual costs to households for participation (waste sorting time + household waste storage + waste drop-off travel costs), minus the following five recycling benefits to society at large which offset the municipal and household direct costs:

- Benefit #1: Market value of pre-processed recyclable materials

| | LB | ML | UB |
|---|---|---|---|
| If average value* of recyclable materials is ($/ton): | $6 | $10 | $25 |
| incremental benefit of 35% goal is (million/year): | $72 | $120 | $300 |

* Average values ($/ton) shown above are for recyclable waste "as collected" from the wastestream (e.g. metal "scrap"), rather than for the resale value of recycled materials "as marketed" after recovery processing at a materials recovery facility (e.g. metal "ingots"). Percent of collected recyclable waste retained in the recovery stage for marketing reportedly ranges from 88% (lumber, fiberboard), to 90% (glass, plastics), 91% (office paper), 95% (newspaper, magazines, books), to 100% (aluminum, steel, corrugated cardboard); source: USEPA "Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks", Exhibit 4-3, p.59, EPA-530-R-02-006, May 2002, http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

# National Annual Recycling Benefits Category #2

- Benefit #2A: Avoided annual costs for MSW collection & landfilling:
  (Note: this avoided cost estimate does not include possible "negative externalities" to the environment associated with MSW landfills & MSW combustors, thus may understate this benefit)***

| | LB | ML | UB |
|---|---|---|---|
| If cost of garbage collection program* is ($/ton): | $43 | $69 | $167 |
| and garbage disposal cost** is ($/ton): | $30 | $36 | $58 |
| then total avoided garbage mgmt cost ($/ton): | $73 | $105 | $225 |
| incremental benefit of 35% goal is (million/year): | $876 | $1,260 | $2,700 |

- Benefit #2B: Avoided foregone future land use from expanded landfill sites:
  Incremental 12 million tons/year to achieve 35% would otherwise consume up to:
  (12 mill.tons) x (2.7 to 8.9 CY waste/ton) x (8 to 22 acres landfill per mill.CY waste) =
  260 to 2,350 acres/year (0.4 to 3.7 sq.miles/year)

* Source: EPA-530-R-01-018, Nov 2001 (garbage costs based on sample of 40 US communities; excludes disposal cost).

** Source: Year 2002 landfill tipping fees from http://wasteinfo.com/data.htm (LB=landfills, ML= weighted-avg if 55.3%landfill & 14.5%combustion; UB= combustion (waste-to-energy).

*** The European Commission identified (Oct 2000, 88 pp.) six categories of negative externalities from landfills: (a) gas emissions to air, (b) soil, surface water & groundwater contamination from leachate, (c) future land-use opportunity cost, (d) disamenities (odor, vermin/insects, visual intrusion); (e) fire/explosion hazard, (f) post-closure monitoring & clean-up costs http://europa.eu.int/comm/environment/enveco/waste/cowi_ext_from_landfill.pdf

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

# National Annual Recycling Benefit Category #3: Household Willingness-to-Pay for Recycling Civic Duty

- 1999 survey* of households "*willingness-to-pay*" for recycling was 74% more than garbage collection cost (+/-1 std.dev. range of 46% to 120%).

- Household reasons for WTP: 53% good for environment; 13% civic duty; 33% unknown.

| | If garbage collect cost is | LB 46% | ML 74% | UP 120% <WTP |
|---|---|---|---|---|
| Lower-bound: | $43/ton | $20/ton | $32/ton | $52/ton |
| Most-likely: | $69/ton | $32/ton | $51/ton | $83/ton |
| Upper-bound: | $167/ton | $77/ton | $124/ton | $200/ton |

- Annual household WTP for recycling (note: only 13% of this WTP applied as a benefit in a following slide to avoid possible double-counting with Benefits #4 & #5):

| | LB | ML | UB |
|---|---|---|---|
| If range in household average WTP is ($/ton): | $20 | $51 | $200 |
| then incremental benefit of 35% goal is (mill./yr): | $240 | $612 | $2,400 |
| And the 13% civic duty component is (mill./yr): | $31 | $80 | $312 |

* Source: Thomas Kinnaman, "Explaining the Growth in Municipal Recycling Programs: The Role of Market and Nonmarket Factors", Public Works Management & Policy, Vol.5, No.1, July 2000, pp.37-51.

In absolute measure, two other published studies estimated household "willingness-to-pay" (WTP) for recycling: (a) Williamson County TN 1992 survey for drop-off program surcharge: $11.74/month (suburban recyclers), $7.07/month (rural recyclers), and $4.05/month (rural non-recyclers), Kelly Tiller et al., "Household Willingness to Pay for Dropoff Recycling", Journal of Agricultural & Resource Economics, Vol. 22, No. 2, pp.310-320, 1997; (b) a 1997 survey of Ogden Utah households revealed a mean WTP for curbside recycling of $2.05/month (range $0.52 to $3.59/mo) incremental to their monthly garbage collection bill, with 72% of residents willing to participate (probability range = 66% to 78%), "David Aadland et al., "Household Valuation of Curbside Recycling", Journal of Environmental Planning & Management, Vol. 42, No. 6, pp.781-799, 1999..

# National Annual Recycling Benefit Category #4

- Benefit #4: Energy: Net reduction (savings) in upstream & downstream lifecycle manufacturing energy consumption, through substitution of recycled for virgin materials (source: Denison, 1996, p.213, based on 1994 Franklin Assoc Btu multiplier):

  - (12.0 million tons/year) x (18.326 million Btus/ton) =
    220,000,000 million Btus/year*
    (0.220 quad* Btus = 37.8 million barrels crude oil equivalency**)

  - @$8.41/million Btu, the additional savings = $1,850 million/year

* Does not include net energy change from the recycling collection/processing compared to garbage collection with landfilling or incineration, to avoid double-counting with unit costs of Benefit #2 compared to recycling unit costs. Recycling collection + MRF processing or recyclables consumes 1.525 million Btus per ton of MSW managed, compared to 0.527 million Btus per ton for MSW garbage collection + landfilling; source: Denison, 1996, p.213).

** 1 quad Btu = 1 quadtrillion Btus = 1 x 10E15 Btus (172.4 million barrels crude oil energy equivalency). US consumed 99.315 quads energy in 2000, consisting of 38.404 quads from crude oil & gas plant liquids (6.62 billion barrels/year or 18.1 million barrels/day), of which 26.046 quads crude oil imported (2.130 billion barrels, or 5.84 million barrels/day).

# National Annual Recycling Benefit Category #5

Benefit #5: Health & Environment: Net reduction in environmental pollutant releases compared to manufacturing with virgin materials:

- Avoided atmospheric emissions (GHG carbon, CO, CH, NOx, SOx, PM)
  - Avoid 491 million tons/year pollutant emissions to air*
  - @$1 to $13,500/ton unit benefit (avoided mortality) = $625 million/year
- Avoided waterborne emissions (BOD, COD, phosphate, solids, metals)
  - Avoid 30 million tons/year pollutant emissions to water*
  - @$0.81 to $2.44/ton unit benefit (avoided water treatment cost) = $44,000/year
- Avoided future land disturbance & future natural resource extraction:
  - Avoid harvesting (logging) trees for pulpwood:
    - (12 mill.tons waste/yr) x (45.4% paper**) x (14 trees/ton***) = 76 mill. trees/year equivalent avoided harvested
    - (76 mill. trees/year) x (1 acre pulpwood fores per 400 trees*****) = 190,000 acres/year avoided forests harvested
  - Avoid mining land for metal ores = 187 to 336 million tons/year mining hidden flows avoided
    - Total metals: (12 mill.tons/yr) x (35.4% metals**) = 4.2 mill.tons/year recycled metals
    - Ferrous metals: (4.2 mill.tons/year) x (72%**) x (48.4 tons hidden flows/ton ore****) = 146 mill.tons
    - Aluminum: (4.2 mill.tons/year) x (13%**) x (59.8 tons hidden flows/ton ore****) = 33 mill.tons
    - Other metals: (4.2 mill.tons/year) x (15%**) x (12 to 249 tons h.flows/ton ore****) = 8 to 157 mill.tons

*Source: Based on USEPA Office of Research & Development life-cycle inventory emissions multipliers in 22 Nov 2002 Tellus Institute memo to OSW (Scott Palmer): http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf

** Source: EPA-530-R-02-001, Table 6, p.43, June 2002, http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm

*** Source: Ratio recycled paper type (EPA-530-R-02-001, June 2002, Table 4, p.36) of 80% groundwood paper @24trees/ton & 20%non-GW paper @12 trees/ton from: http://www.conservatree.org/learn/Enviro_Issues/TreeStats.shtml

**** Source: Artti Juutinen, "Industrial Ecology of the Metal Sector", Table 1, 2000, http://www.cc.jyu.fi/helsie/pdf/juutinen.pdf
Hidden flows = all material flows needed in metals mining & processing based on a life-cycle inventory approach.

*****Source: trees/acre recycled paper equivalency from: http://www.rirrc.org/site/educational/rguide_paper.asp

# Other National Annual Recycling Benefits

- Sustainable economy: Meet economic and environmental sustainability objectives such as:
  (a) provide future generations with same resource opportunities as current generation,
  (b) don't exceed ecological "*carrying capacity*", and
  (c) reduce "*ecological footprint*" of economy.

- Industrial ecology: Achieve symbiotic, closed-loop, material flow connections between households and industrial processes, whereby discarded household materials ("garbage", "wastes") are recovered by industry as inputs rather than discarded/disposed into the environment (i.e. zero waste).

# 2C.3 ($millions/year)
# Benefit-Cost Analysis of OSW's 35% MSW Recycling Goal

| | LB | ML | UB |
|---|---|---|---|
| ■ Incremental total benefits of 35% goal ($million/year): | | | |
| ❑ #1 Market value of recyclable materials | $72 | $120 | $300 |
| ❑ #2 Avoided garbage mgmt costs | $876 | $1,260 | $2,700 |
| ❑ #3 Household WTP (@13% civic duty) = | $31 | $80 | $312 |
| ❑ #4 Downstream energy reduction* = | $1,295 | $1,850 | $2,405 |
| ❑ #5 Life-cycle pollutant reduction* = | $437 | $625 | $813 |
| Total annual benefits (if non-duplicative) = | $2,711 | $3,935 | $6,530 |
| ■ Net benefits of 35% goal ($million/year): | | | |
| ❑ Annual incremental direct costs = | $420 | $1,176 | $1,944 |
| ❑ Net benefits (benefits minus costs) = | $2,291 | $2,759 | $4,586 |
| ■ Benefit-Cost Ratio (benefits/costs)**: | **6.45** | **3.35** | **3.36** |

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

* LB and UB estimates assigned to benefit categories #4 and #5 based on -/+30% of ML value, respectively.

** In comparison to this national benefit-cost ratio estimate, one published study estimated a rural county-wide benefit-cost ratio of 8.8, based on a county dropoff recycling program cost (1992) of $0.46/month per household, relative to a survey household willingness-to-pay of $4.05/month for rural non-recyclers; Kelly Tiller et al., "Household Willingness to Pay for Dropoff Recycling", Journal of Agricultural & Resource Economics, Vol.22, No.2, pp.310-320, 1997.

# 2C.3 ($/ton average)
# Benefit-Cost Analysis of OSW's 35% MSW Recycling Goal

| | LB | ML | UB |
|---|---|---|---|
| ■ Incremental total benefits of 35% goal ($/ton): | | | |
| ❑ #1 Market value of recyclable materials | $6 | $10 | $25 |
| ❑ #2 Avoided garbage mgmt costs | $73 | $105 | $225 |
| ❑ #3 Household WTP (@13% civic duty) = | $3 | $7 | $26 |
| ❑ #4 Downstream energy reduction* = | $108 | $154 | $200 |
| ❑ #5 Life-cycle pollutant reduction* = | $36 | $52 | $68 |
| Total annual benefits (if non-duplicative) = | $226 | $328 | $544 |
| ■ Net benefits of 35% goal ($/ton): | | | |
| ❑ Annual incremental direct costs = | $35 | $98 | $162 |
| ❑ Net benefits (benefits minus costs) = | $191 | $230 | $382 |
| ■ Benefit-Cost Ratio (benefits/costs)**: | **6.45** | **3.35** | **3.36** |

LB = lower-bound estimate (-1 std.dev) ML= most likely UB = upper-bound (+1 std.dev)

* LB and UB estimates assigned to benefit categories #4 and #5 based on -/+30% of ML value, respectively.

** In comparison to this national benefit-cost ratio estimate, one published study estimated a rural county-wide benefit-cost ratio of 8.8, based on a county dropoff recycling program cost (1992) of $0.46/month per household, relative to a survey household willingness-to-pay of $4.05/month for rural non-recyclers; Kelly Tiller et al., "Household Willingness to Pay for Dropoff Recycling", Journal of Agricultural & Resource Economics, Vol.22, No.2, pp.310-320, 1997.

# 2C.4

# Potential Impact of 35% Recycling Goal on US Employment

## A. Employment Baseline Reference Data (source: 1997 Economic Census):

| MSW Mgt | NAICS | 1997 estabs | 1997 workers | 1997 revenue (billions) | 1997 payroll (millions) | 1997 tons MSW managed | 1997 tons/yr per worker | 1997 avg revenue per ton | 1997 avg worker payroll |
|---|---|---|---|---|---|---|---|---|---|
| Recycling | 562920 | 765 | 10,846 | $1.299 | $283.5 | 59.03 | 5,443 | $22.01 | $26,136 |
| Landfill | 562212 | 1,403 | 27,454 | $5.493 | $887.1 | 125.54 | 4,573 | $43.76 | $32,311 |
| Combust. | 562213 | 105 | 2,976 | $1.129 | $132.6 | 34.79 | 11,689 | $32.44 | $44,554 |
| Column totals = | | 2,273 | 41,276 | $7.921 | $1,303.1 | 219.36 | 5,314 | $36.11 | $31,572 |

Note: Solid waste collection services (NAICS 562111) employment not analyzed; assumes MSW collection quantity is unchanged.

## B. Potential Impact on Employment (2001 update year; parentheses indicate decrease):

| MSW Mgt | 35% increment (mill. tons/yr) | Change in employment (workers) | Change in revenues ($millions) | Change in payroll ($millions) |
|---|---|---|---|---|
| Recycling | 12.0 | 2,208 | $288 | $76 |
| Landfill | (9.5) | (2,079) | ($453) | ($89) |
| Combust. | (2.5) | (215) | ($89) | ($13) |
| Column totals = 0 | | **(86)** | ($253) | ($25) |

Note: One published study postulates the following macroeconomic implications of recycling: "[E]xpansion of recycling will reduce dependence on imports and thus improve the balance-of-payments. Furthermore, and autonomous reduction in imports is then assumed to create a multiplier effect, as there is a net injection to the circular flow of income, causing GNP to rise. Finally, the higher GNP is assumed to create an expansion in the requirement of labor, thus reducing unemployment." This study examined two countries and estimated 0.29% and 2.3% annual increases in GNP from 5% and 40% recycling rates, respectively (for Italy), and 0.88% and 1.76% annual increases in GNP from 5% and 10% recycling rate increases, respectively (for United Kingdom); V. Rich et al., "Macroeconomic Implications of Recycling: A Response to Di Vita," Resources Policy, Vol.25, pp.141-142, 1999.

# 2D. Potential* for Recycling Beyond 35%:

2D.1 Maximum economically-beneficial recycling “net cost”
2D.2 Potential impact of meeting unmet state goals (2010)
2D.3 Potential impact of expanded recycling population coverage
2D.4 Sample of opinions on maximum recycling rates achievable
2D.5 Enhancing national recycling rates
2D.6 Role of recycling in environmental protection

* Note: The following slides present a “supply-side” portrayal of MSW recycling potential; achievement of future potential depends upon “demand-side” complementarity (i.e. capacity of industries to purchase and utilize increasing annual quantities of recyclable materials).

# 2D.1 Estimate of Recycling "Net Cost" (Pooled Data from 30 Cities)

**Pooled Data (3 data sets): MSW Recycling "Net Cost" (Collection Cost + MRF Processing Cost - Material Revenues)**

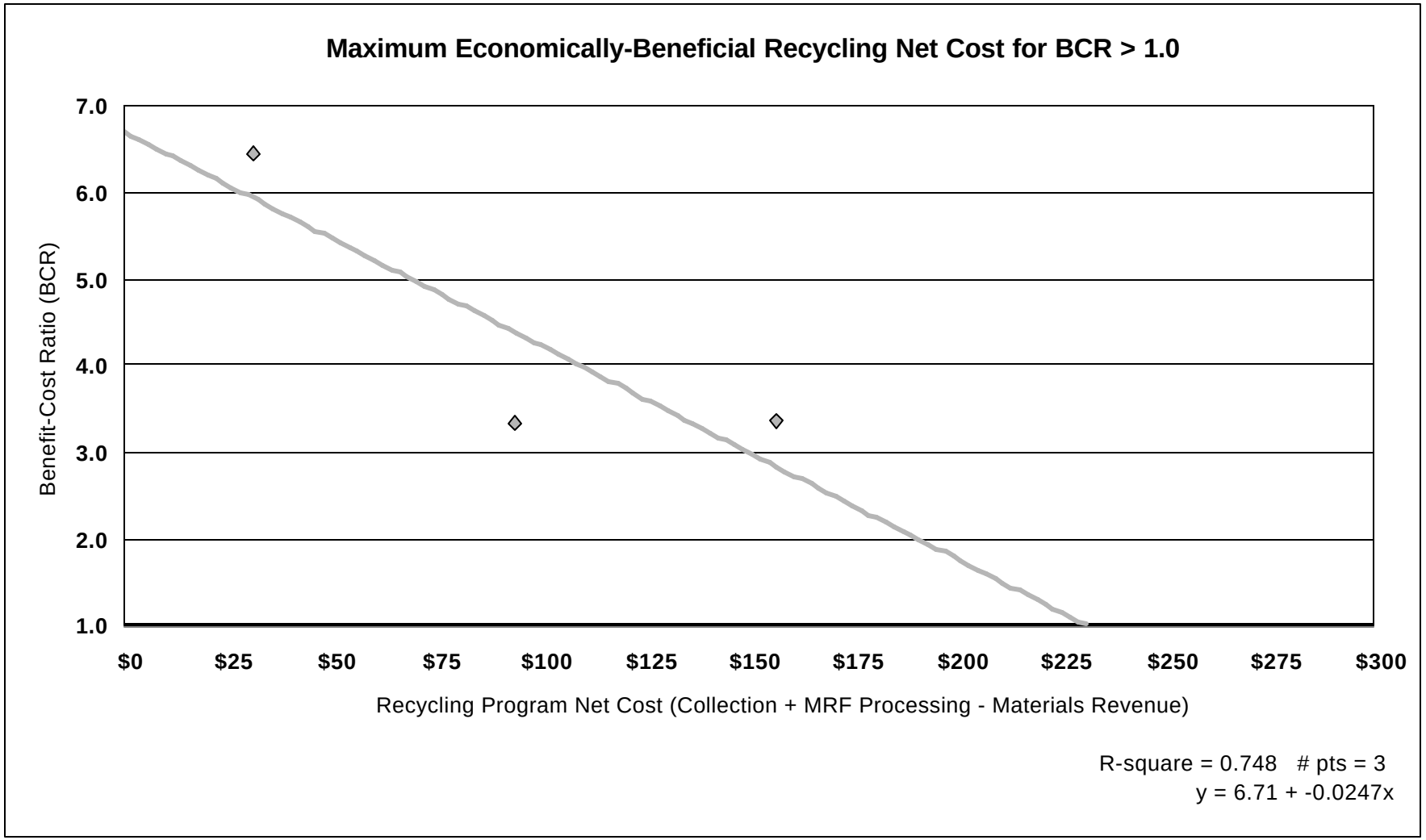
**A. Reference Data:**

| A | B | C | D | E (D/B) | F (B+C-D) | G | H | I |
|---|---|---|---|---|---|---|---|---|
| Data item | Recycling program cost ($/ton) | Recycling processing ($/ton) | Materials revenues ($/ton) | Revenue offset percentage | Recycling net cost ($/ton) | Data year | Data source | Type |
| 1 | $73.00 | $14.00 | $9.07 | 12.4% | $77.93 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 2 | $38.72 | included | $7.98 | 20.6% | $30.74 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 3 | $46.00 | $55.00 | $4.81 | 10.5% | $96.19 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 4 | $88.91 | $100.00 | $17.01 | 19.1% | $171.90 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 5 | $51.29 | unknown | $16.99 | 33.1% | $34.30 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 6 | $128.00 | unknown | $10.61 | 8.3% | $117.39 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 7 | $118.00 | $42.00 | $12.65 | 10.7% | $147.35 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 8 | $196.00 | included | $14.64 | 7.5% | $181.36 | 1996$ | EPA-530-R-99-013 | Curb+dropoff |
| 9 | $36.00 | excluded | $36.00 | 100.0% | $0.00 | 1993$ | EPA-600-R-95-109 | Dropoff |
| 10 | $17.16 | excluded | $17.16 | 100.0% | $0.00 | 1993$ | EPA-600-R-95-109 | Dropoff |
| 11 | $23.99 | excluded | $23.99 | 100.0% | $0.00 | 1993$ | EPA-600-R-95-109 | Dropoff |
| 12 | $4.94 | excluded | $4.94 | 100.0% | $0.00 | 1993$ | EPA-600-R-95-109 | Dropoff |
| 13 | $4.22 | excluded | $4.22 | 100.0% | $0.00 | 1993$ | EPA-600-R-95-109 | Dropoff |
| 14 | $7.71 | excluded | $7.71 | 100.0% | $0.00 | 1993$ | EPA-600-R-95-109 | Dropoff |
| 15 | $4.13 | excluded | $4.13 | 100.0% | $0.00 | 1993$ | EPA-600-R-95-109 | Dropoff |
| 16 | $3 | excluded | $0.01 | 0.5% | $2.69 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 17 | $187 | excluded | $18.91 | 10.1% | $168.33 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 18 | $64 | excluded | $2.49 | 3.9% | $61.36 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 19 | $210 | excluded | $2.46 | 1.2% | $207.65 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 20 | $17 | excluded | $1.00 | 5.8% | $16.35 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 21 | $98 | excluded | $26.84 | 27.3% | $71.58 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 22 | $12 | excluded | $3.53 | 28.2% | $8.96 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 23 | $41 | excluded | $37.66 | 91.6% | $3.44 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 24 | $135 | excluded | $0.58 | 0.4% | $134.05 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 25 | $92 | excluded | $4.33 | 4.7% | $87.53 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 26 | $34 | excluded | $0.04 | 0.1% | $34.43 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 27 | $84 | excluded | $13.04 | 15.5% | $70.88 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 28 | $124 | excluded | $17.11 | 13.8% | $107.33 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 29 | $120 | excluded | $44.45 | 36.9% | $76.01 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| 30 | $167 | excluded | $32.10 | 19.2% | $134.95 | 2002$ | Waste News Feb 2003 | Curb+dropoff |
| Min = | $2.71 | | $0.01 | 0.1% | $0.00 | | | |
| Max = | $210.11 | | $44.45 | 100.0% | $207.65 | | | |
| Median = | $57.57 | | $9.84 | 17% | $66.12 | | | |
| Mean = | $74.27 | | $13.22 | 36.0% | $68.09 | | | |

**B. Normalized to 2002$:**

| J | K | L | M | N (K+L-M) | O (K+L) |
|---|---|---|---|---|---|
| Data item | Recycling program cost ($/ton) | Recycling processing ($/ton) | Materials revenues ($/ton) | Recycling net cost ($/ton) | Recycling total cost ($/ton) |
| 1 | $82.57 | $15.84 | $10.26 | $88 | $98.41 |
| 2 | | | $9.03 | | |
| 3 | $52.03 | $62.21 | $5.44 | $109 | $114.24 |
| 4 | $100.57 | $113.11 | $19.24 | $194 | $213.68 |
| 5 | $58.02 | | $19.22 | $39 | $58.02 |
| 6 | $144.78 | | $12.00 | $133 | $144.78 |
| 7 | $133.47 | $47.51 | $14.31 | $167 | $180.98 |
| 8 | | | $16.56 | | |
| 9 | $43.53 | $33 | $43.53 | $33 | $76.34 |
| 10 | $20.75 | $33 | $20.75 | $33 | $53.55 |
| 11 | $29.01 | $33 | $29.01 | $33 | $61.81 |
| 12 | $5.97 | $33 | $5.97 | $33 | $38.78 |
| 13 | $5.10 | $33 | $5.10 | $33 | $37.91 |
| 14 | $9.32 | $33 | $9.32 | $33 | $42.13 |
| 15 | $4.99 | $33 | $4.99 | $33 | $37.80 |
| 16 | | | | | |
| 17 | $187 | $33 | $18.91 | $201 | $220.04 |
| 18 | $64 | $33 | $2.49 | $94 | $96.65 |
| 19 | $210 | $33 | $2.46 | $240 | $242.91 |
| 20 | $17 | $33 | $1.00 | $49 | $50.16 |
| 21 | $98 | $33 | $26.84 | $104 | $131.22 |
| 22 | $12 | $33 | $3.53 | $42 | $45.29 |
| 23 | $41 | $33 | $37.66 | $36 | $73.90 |
| 24 | $135 | $33 | $0.58 | $167 | $167.43 |
| 25 | $92 | $33 | $4.33 | $120 | $124.67 |
| 26 | $34 | $33 | $0.04 | $67 | $67.28 |
| 27 | $84 | $33 | $13.04 | $104 | $116.72 |
| 28 | $124 | $33 | $17.11 | $140 | $157.24 |
| 29 | $120 | $33 | $44.45 | $109 | $153.27 |
| 30 | $167 | $33 | $32.10 | $168 | $199.85 |
| Min = | $5 | $16 | $0.04 | $33 | $38 |
| Max = | $210 | $113 | $44 | $240 | $243 |
| Median = | $64 | $55 | $12 | $94 | $98 |
| Mean = | $77 | $60 | $15 | $96 | $111 |
| Std.dev = | $60 | $41 | $13 | $63 | $63 |
| Median -1SD = | $4 | $14 | $6 | $32 | $35 |
| Median + 1SD = | $124 | $95 | $25 | $157 | $162 |

# Maximum Economically-Beneficial Recycling "Net Cost" = $225/ton
(projection of X-Y plot based on LB, ML, UB pooled data in cost & benefits pages)



# 2D.2

## National MSW Recycling Rate Potential for Year 2010, Implied by 33.2 Million Tons/Year Unmet & Future State Recycling Goals

Franklin Associates data:

- 69.9 million tons/year MSW recycled (2000)
- 69.9 + 33.2 = 103.1 MTY MSW recycling potential year 2010
- (103.1 MTY recycled)/(231.9 MTY MSW generated in 2000) = **45%**

BioCycle magazine data:

- 130.5 million tons/year MSW recycled (2000)
- 130.5 + 33.2 = 163.7 MTY MSW recycling potential year 2010
- (163.7 MTY recycled)/(409.0 MTY MSW generated in 2000) = **40%**

# Urban & Rural MSW Recycling Penetration (2000)

**Estimate of Large Urban, Small Urban & Rural Populations Served by MSW Recycling (2000)**

| | | A. State Total MSW Recycling Penetration: | | | | | | B. Large Urban Recycling Penetration: | | | C. Small Urban Recycling Penetration: | | | | D. Rural Penetration: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D (10%xC/90%) | E (C+D) | F (E/D) | G | H (E/G) | I (GxH if<100%) | J | K (G+J) | L (E/K) | M (KxL-V) | N (B-K) | O (N-B) | P (E-K)/N |
| | | | | BioCycle | OSW estimate | OSW estimate | | | | | | | | | | | |
| | | 2000 | | curbside | of dropoff | total recycling | % of popltn | Urbanized | % of UA | UA popltn | Urbanized | | % of UA+UC | UC popltn | | | % of rural |
| | | housing | 2000 | population | population | population | served by | area (UA) | served by | served by | cluster (UC) | UA + UC | served by | served by | Rural | | served by |
| Item | State | units | population | served 2000 | 10.0% | served | recycling | population | recycling | recycling | population | population | recycling | recycling | population | % rural | recycling |
| 1 | Alabama | 1,963,711 | 4,447,100 | 1,100,000 | 122,222 | 1,222,222 | 27.5% | 1,941,208 | 63.0% | 1,222,222 | 524,465 | 2,465,673 | 49.6% | 0 | 1,981,427 | 44.6% | 0.0% |
| 2 | Alaska | 260,978 | 626,932 | 0 | 0 | 0 | 0.0% | 277,670 | 0.0% | 0 | 133,587 | 411,257 | 0.0% | 0 | 215,675 | 34.4% | 0.0% |
| 3 | Arizona | 2,189,189 | 5,130,632 | 2,430,000 | 270,000 | 2,700,000 | 52.6% | 3,908,163 | 69.1% | 2,700,000 | 615,372 | 4,523,535 | 59.7% | 0 | 607,097 | 11.8% | 0.0% |
| 4 | Arkansas | 1,173,043 | 2,673,400 | | | | | 860,747 | | | 543,432 | 1,404,179 | | | 1,269,221 | 47.5% | |
| 5 | California | 12,214,549 | 33,871,648 | 31,146,000 | 0 | 31,146,000 | 92.0% | 29,950,008 | 104.0% | 29,950,008 | 2,039,655 | 31,989,663 | 97.4% | 1,195,992 | 1,881,985 | 5.6% | 0.0% |
| 6 | Colorado | 1,808,037 | 4,301,261 | | | | | 3,212,849 | | | 9,238 | 3,222,087 | | | 1,079,174 | 25.1% | |
| 7 | Connecticu | 1,385,975 | 3,405,565 | 3,405,565 | 0 | 3,405,565 | 100.0% | 2,848,497 | 119.6% | 2,848,497 | 139,562 | 2,988,059 | 114.0% | 139,562 | 417,506 | 12.3% | 100.0% |
| 8 | DC | 274,845 | 572,059 | | | | | 531,032 | | | 0 | 531,032 | | | 41,027 | 7.2% | |
| 9 | Delaware | 343,072 | 783,600 | 4,000 | 444 | 4,444 | 0.6% | 572,059 | 0.8% | 4,444 | 96,726 | 668,785 | 0.7% | 0 | 114,815 | 14.7% | 0.0% |
| 10 | Florida | 7,302,947 | 15,982,378 | 8,500,000 | 944,444 | 9,444,444 | 59.1% | 13,470,104 | 70.1% | 9,444,444 | 799,916 | 14,270,020 | 66.2% | 0 | 1,712,358 | 10.7% | 0.0% |
| 11 | Georgia | 3,281,737 | 8,186,453 | | | | | 5,010,117 | | | 854,046 | 5,864,163 | | | 2,322,290 | 28.4% | |
| 12 | Hawaii | 460,542 | 1,211,537 | 400,000 | 44,444 | 444,444 | 36.7% | 835,912 | 53.2% | 444,444 | 272,313 | 1,108,225 | 40.1% | 0 | 103,312 | 8.5% | 0.0% |
| 13 | Idaho | 527,824 | 1,293,953 | | | | | 603,808 | | | 255,689 | 859,497 | | | 434,456 | 33.6% | |
| 14 | Illinois | 4,885,615 | 12,419,293 | 8,051,000 | 894,556 | 8,945,556 | 72.0% | 9,737,473 | 91.9% | 8,945,556 | 1,172,047 | 10,909,520 | 82.0% | 0 | 1,509,773 | 12.2% | 0.0% |
| 15 | Indiana | 2,532,319 | 6,080,485 | 4,170,000 | 463,333 | 4,633,333 | 76.2% | 3,410,932 | 135.8% | 3,410,932 | 893,079 | 4,304,011 | 107.7% | 893,079 | 1,776,474 | 29.2% | 18.5% |
| 16 | Iowa | 1,232,511 | 2,926,324 | 1,983,000 | 220,333 | 2,203,333 | 75.3% | 1,114,790 | 197.6% | 1,114,790 | 671,979 | 1,786,769 | 123.3% | 671,979 | 1,139,555 | 38.9% | 36.6% |
| 17 | Kansas | 1,131,200 | 2,688,418 | 1,223,000 | 135,889 | 1,358,889 | 50.5% | 1,207,832 | 112.5% | 1,207,832 | 712,837 | 1,920,669 | 70.8% | 151,057 | 767,749 | 28.6% | 0.0% |
| 18 | Kentucky | 1,750,927 | 4,041,769 | 590,000 | 65,556 | 655,556 | 16.2% | 1,566,760 | 41.8% | 655,556 | 687,040 | 2,253,800 | 29.1% | 0 | 1,787,969 | 44.2% | 0.0% |
| 19 | Louisiana | 1,847,181 | 4,468,976 | | | | | 2,535,614 | | | 710,051 | 3,245,665 | | | 1,223,311 | 27.4% | |
| 20 | Maine | 651,901 | 1,274,923 | 487,000 | 54,111 | 541,111 | 42.4% | 313,952 | 172.4% | 313,952 | 198,926 | 512,878 | 105.5% | 198,926 | 762,045 | 59.8% | 3.7% |
| 21 | Maryland | 2,145,283 | 5,296,486 | 3,600,000 | 400,000 | 4,000,000 | 75.5% | 4,247,989 | 94.2% | 4,000,000 | 310,679 | 4,558,668 | 87.7% | 0 | 737,818 | 13.9% | 0.0% |
| 22 | Massachus | 2,621,989 | 6,349,097 | 4,832,000 | 536,889 | 5,368,889 | 84.6% | 5,635,129 | 95.3% | 5,368,889 | 166,238 | 5,801,367 | 92.5% | 0 | 547,730 | 8.6% | 0.0% |
| 23 | Michigan | 4,234,279 | 9,938,444 | 2,951,000 | 327,889 | 3,278,889 | 33.0% | 6,578,451 | 49.8% | 3,278,889 | 841,006 | 7,419,457 | 44.2% | 0 | 2,518,987 | 25.3% | 0.0% |
| 24 | Minnesota | 2,065,946 | 4,919,479 | 3,700,000 | 411,111 | 4,111,111 | 83.6% | 2,711,750 | 151.6% | 2,711,750 | 778,309 | 3,490,059 | 117.8% | 778,309 | 1,429,420 | 29.1% | 43.4% |
| 25 | Mississippi | 1,161,953 | 2,844,658 | 325,000 | 36,111 | 361,111 | 12.7% | 679,928 | 53.1% | 361,111 | 707,423 | 1,387,351 | 26.0% | 0 | 1,457,307 | 51.2% | 0.0% |
| 26 | Missouri | 2,442,017 | 5,595,211 | | | | | 3,090,644 | | | 792,798 | 3,883,442 | | | 1,711,769 | 30.6% | |
| 27 | Montana | 412,633 | 902,195 | | | | | 234,195 | | | 253,683 | 487,878 | | | 414,317 | 45.9% | |
| 28 | Nebraska | 722,668 | 1,711,263 | 500,000 | 55,556 | 555,556 | 32.5% | 805,111 | 69.0% | 555,556 | 388,614 | 1,193,725 | 46.5% | 0 | 517,538 | 30.2% | 0.0% |
| 29 | Nevada | 827,457 | 1,998,257 | 1,622,000 | 180,222 | 1,802,222 | 90.2% | 1,676,309 | 107.5% | 1,676,309 | 152,337 | 1,828,646 | 98.6% | 125,913 | 169,611 | 8.5% | 0.0% |
| 30 | New Hamps | 547,024 | 1,235,786 | 511,000 | 56,778 | 567,778 | 45.9% | 551,828 | 102.9% | 551,828 | 180,486 | 732,314 | 77.5% | 15,950 | 503,472 | 40.7% | 0.0% |
| 31 | New Jersey | 3,310,275 | 8,414,350 | 7,500,000 | 833,333 | 8,333,333 | 99.0% | 7,753,792 | 107.5% | 7,753,792 | 185,295 | 7,939,087 | 105.0% | 185,295 | 475,263 | 5.6% | 83.0% |
| 32 | New Mexic | 780,579 | 1,819,046 | 400,000 | 44,444 | 444,444 | 24.4% | 862,344 | 51.5% | 444,444 | 501,157 | 1,363,501 | 32.6% | 0 | 455,545 | 25.0% | 0.0% |
| 33 | New York | 7,679,307 | 18,976,457 | 17,230,000 | 0 | 17,230,000 | 90.8% | 15,504,619 | 111.1% | 15,504,619 | 1,097,963 | 16,602,582 | 103.8% | 1,097,963 | 2,373,875 | 12.5% | 26.4% |
| 34 | North Carol | 3,523,944 | 8,049,313 | 3,500,000 | 388,889 | 3,888,889 | 48.3% | 3,760,871 | 103.4% | 3,760,871 | 1,088,611 | 4,849,482 | 80.2% | 128,018 | 3,199,831 | 39.8% | 0.0% |
| 35 | North Dako | 289,677 | 642,200 | 100,000 | 11,111 | 111,111 | 17.3% | 230,797 | 48.1% | 111,111 | 128,161 | 358,958 | 31.0% | 0 | 283,242 | 44.1% | 0.0% |
| 36 | Ohio | 4,783,051 | 11,353,140 | | | | | 7,311,293 | | | 1,471,036 | 8,782,329 | | | 2,570,811 | 22.6% | |
| 37 | Oklahoma | 1,514,400 | 3,450,654 | 1,057,000 | 117,444 | 1,174,444 | 34.0% | 1,483,638 | 79.2% | 1,174,444 | 770,925 | 2,254,563 | 52.1% | 0 | 1,196,091 | 34.7% | 0.0% |
| 38 | Oregon | 1,452,709 | 3,421,399 | 2,633,000 | 292,556 | 2,925,556 | 85.5% | 1,976,124 | 148.0% | 1,976,124 | 718,020 | 2,694,144 | 108.6% | 718,020 | 727,255 | 21.3% | 31.8% |
| 39 | Pennsylvar | 5,249,750 | 12,281,054 | 8,800,000 | 977,778 | 9,777,778 | 79.6% | 8,210,985 | 119.1% | 8,210,985 | 1,253,116 | 9,464,101 | 103.3% | 1,253,116 | 2,816,953 | 22.9% | 11.1% |
| 40 | Rhode Islar | 439,837 | 1,048,319 | 890,000 | 98,889 | 988,889 | 94.3% | 928,119 | 106.5% | 928,119 | 25,027 | 953,146 | 103.7% | 25,027 | 95,173 | 9.1% | 37.6% |
| 41 | South Caro | 1,753,670 | 4,012,012 | 1,676,000 | 186,222 | 1,862,222 | 46.4% | 1,873,821 | 99.4% | 1,862,222 | 553,303 | 2,427,124 | 76.7% | 0 | 1,584,888 | 39.5% | 0.0% |
| 42 | South Dako | 323,208 | 754,844 | | | | | 194,584 | | | 196,843 | 391,427 | | | 363,417 | 48.1% | |
| 43 | Tennessee | 2,439,443 | 5,689,283 | | | | | 2,964,722 | | | 655,296 | 3,620,018 | | | 2,069,265 | 36.4% | |
| 44 | Texas | 8,157,575 | 20,851,820 | 5,000,000 | 555,556 | 5,555,556 | 26.6% | 14,795,862 | 37.5% | 5,555,556 | 2,408,419 | 17,204,281 | 32.3% | 0 | 3,647,539 | 17.5% | 0.0% |
| 45 | Utah | 768,594 | 2,233,169 | | | | | 1,748,080 | | | 222,264 | 1,970,344 | | | 262,825 | 11.8% | |
| 46 | Vermont | 294,382 | 608,827 | 325,000 | 36,111 | 361,111 | 59.3% | 105,365 | 342.7% | 105,365 | 127,083 | 232,448 | 155.4% | 127,083 | 376,379 | 61.8% | 34.2% |
| 47 | Virginia | 2,904,192 | 7,078,515 | 1,144,000 | 127,111 | 1,271,111 | 18.0% | 4,713,302 | 27.0% | 1,271,111 | 456,653 | 5,169,955 | 24.6% | 0 | 1,908,560 | 27.0% | 0.0% |
| 48 | Washingtor | 2,451,075 | 5,894,121 | 4,787,000 | 531,889 | 5,318,889 | 90.2% | 4,303,803 | 123.6% | 4,303,803 | 527,303 | 4,831,106 | 110.1% | 527,303 | 1,063,015 | 18.0% | 45.9% |
| 49 | West Virgir | 844,623 | 1,808,344 | | | | | 512,427 | | | 320,353 | 832,780 | | | 975,564 | 53.9% | |
| 50 | Wisconsin | 2,321,144 | 5,363,675 | 3,173,000 | 352,556 | 3,525,556 | 65.7% | 2,842,494 | 124.0% | 2,842,494 | 821,149 | 3,663,643 | 96.2% | 683,062 | 1,700,032 | 31.7% | 0.0% |
| 51 | Wyoming | 223,854 | 493,782 | 20,000 | 2,222 | 22,222 | 4.5% | 125,921 | 17.6% | 22,222 | 195,423 | 321,344 | 6.9% | 0 | 172,438 | 34.9% | 0.0% |
| | United States | 115,904,641 | 281,421,906 | 139,765,565 | 9,776,000 | 149,541,565 | 53.1% | 192,323,824 | 71.0% | 136,594,292 | 29,624,933 | 221,948,757 | | 8,915,653 | 59,473,149 | 21.1% | 1.4% |
| | | | | 49.7% | 3.5% | 53.1% | | 68.3% | | | 10.5% | 78.9% | 5,419,716 | 30.1% | 21.1% | | 853,775 |

Bureau of Census definitions: UA = contiguous census block groups usually >1,000 ppsm & together >50,000 total population; UC = block groups usually <1,000 ppsm & together 2,500 to 50,000 total population.

# 2D.3

# Future National Recycling Rate if Expand Population Coverage

A. Proportion of US Population Served by MSW Recycling Programs (2000):

| Population category | 2000 US population (millions) | Population served by recycling* | | Unserved gap | |
|---|---|---|---|---|---|
| Large urban | 192.3 | 136.6 | 71% | 55.7 | 29% |
| Small urban | 29.6 | 8.9 | 30% | 20.7 | 70% |
| Rural | 59.5 | 0.9 | 1.4% | 58.6 | 98.6% |
| Total US = | 281.4 | 146.4 | 52% | 135.0 | 48% |

B. Potential Future National MSW Recycling Rate if Expand Population Coverage:

| Urban category | Expanded population served (millions) | Potential Rate 2000 Baselines Franklin | BioCycle |
|---|---|---|---|
| If 100% large urban | 146.4+55.7 = 202.1 (72%) | **42%** | **44%** |
| If 100% large + small | 146.4+55.7+20.7 = 222.8 (79%) | **46%** | **49%** |
| If 100% urban + rural** | 281.4 (100%) | **58%**** | **61%**** |

* Based on BioCycle magazine, Dec. 2001, Table 6, p.47.

** In many states, expansion of recycling programs to 100% rural coverage may not be economically-beneficial because of higher truck collection costs for longer travel distances in low-density population areas; although one state (CT with 12.3% rural pop.) reports 100% of population served in 2000.

# 2D.4
# Sample of Opinions on Maximum Recycling Rates

- 1990 opinion: Institute for Local Self-Reliance: From "*Beyond 40 Percent: Record-Setting Recycling & Composting Programs*" (1990): "When our first volume 'Beyond 25 Percent' was published in May 1989, only 33% of the 15 best recycling and composting programs were recovering more than 40% of their waste streams. Of the 17 programs in this study concluded only one year later, 60% are recovering **40%** or more… All the programs documented in this report -- even the best – can increase their materials recovery levels."

- 1997 opinion: Finnish Forest Research Institute: "A Post-Consumer Waste Management Model for Determining Optimal Levels of Recycling & Landfilling" (1997): "The present study examines the optimal recycling rate for MSW. The benefits from recycling are included in the simulation using the results of a recent contingent valuation study. The results of the present research suggest that mandates achieving **50%** recycling in municipalities are not far-fetched and are both economically and environmentally justified."

- 1999 opinion: City of Los Angeles Solid Resources Collection Division: "Los Angeles recently conducted a study that indicated recyclable materials comprised 40% of the total [Los Angeles] waste stream… We know it's not possible to recycle the entire 40%, but we're confident we can reach a **30%** residential recycling rate."

- 1999 opinion: New York City Bureau of Waste Prevention, Reuse & Recycling: "People are beginning to see that 25% may be a limit for cities… It's a different situation in, say, Seattle, where there is an enormous amount of yard waste; when you look at what's available in a residential sector's trash and what has a market, you're looking at an upper limit close to **25%."**

- 2003 opinion: Franklin Assoc.: From "*Recycling – Is 50% A Reasonable Goal?*" (2003): "[W]e believe it will not be possible to reach a 50% recovery rate by 2010 without draconian measures… If some products generated in large quantities (i.e. yard trimmings, food wastes, mixed papers) could be pushed to higher recovery levels, **40%** might be achieved with a good deal of effort."

# 2D.5
# Enhancing Recycling's Economic Potential

"Recycling is more expensive for communities than it needs to be, partly because traditional recycling tries to force materials into more lifetimes than they were designed for – a complicated and messy conversion, and one that itself expends energy and resources. Very few objects of modern consumption were designed with recycling in mind. **If the [recycling] process is truly to save money and materials, products must be designed from the very beginning to be recycled** or even "upcycled" – a term we use to describe the return to industrial systems of materials with improved, rather than degraded, quality."

Source: William McDonough & Michael Braungart, "The Next Industrial Revolution", The Atlantic Monthly, Vol. 282, No. 4, Oct 1998, pp.82-92; http://www.theatlantic.com/issues/98oct/industry.htm

# Enhancing Recycling's Economic Potential (cont'd)

"Economic welfare analysis tells us that the amount of recycling undertaken by consumers will be less than optimal for two reasons:

- First, recycling creates a **positive externality** in that everyone benefits from my recycling efforts (saving landfill space and reducing landfill costs). In the absense of a one-to-one correspondence between those who make the effort and those who reap the benefit, many will not make the effort voluntarily.
- Second, recycling is an **intergenerational public good**. Our recycling efforts today will help to eliminate a potential problem in the future. Given the myopic time preference of most individuals, people will undervalue the current benefits of recycling.

The above two factors cause the **private marginal benefit** from recycling to be less than the **social marginal benefit**. From society's perspective, not enough recycling will be done by individuals because they cannot capture, or are not compensated for, all of the benefits of their efforts. Therefore, **any large scale recycling program must be government initiated, either through mandatory regulations or economic incentives**. Considering the magnitude of the problem, it is only a matter of time before legislation is introduced to implement recycling on a national level."

Source: Vijaya Duggal et al., School of Management, Widener Univ., "Recycling: An Economic Analysis", Eastern Economic Journal, Vol. XVII, No. 3, July-Sept 1991, p.352.)

# Economic Incentives for Enhancing Recycling: Empirical Results from 1997 Study* of All 351 Towns in Mass.

- Unit pricing: A community implementing a quantity-based unit pricing system, rather than a flat monthly fee, for MSW garbage collection can expect its annual recycling rate to be **6.6 % points** higher than if it had used an alternative garbage collection pricing approach. Because flat fees are not quantity-dependent, they give households no incentive to economize on waste generation or disposal, a classic market failure.
- Curbside service: An additional increase of **5.5 % points** in the annual recycling rate (totaling **12.1 % points**) is predicted if the MSW garbage unit pricing system is accompanied by the provision of curbside recycling services, which by itself should increase the annual recycling rate by **4.2 % points**.
- Disposal cost: Similarly, if policy initiatives elevate the cost of garbage disposal, the *relative cost* of recycling falls, and aggregate annual recycling rates should rise. Conversely, the public provision of free MSW garbage collection decreases the opportunity cost of disposal relative to recycling, thereby lowering the annual recycling rate (MSW landfill tipping fees in 2003 average only $30/ton).
- MRF: A community using a state-funded materials recovery facility (MRF) can expect to achieve an average increase of **9.5 % points** in its annual recycling rate, because free access to a state-funded MRF may allow relatively small communities to experience savings in recycling costs typically associated only with more densely-populated communities, translating into higher recycling levels.
- Education: Each additional grant dollar awarded per household for recycling education should increase a community's annual recycling rate by **2.6 % points**.
- Equipment: Grants for recycling equipment should encourage public provision of recycling services by lowering the cost of doing so, which should in turn lower resident's opportunity cost of recycling, leading to a higher recycling rate.

* Source: Scott Callan & Janet Thomas, "The Impact of State & Local Policies on The Recycling Effort", Eastern Economic Journal, Vol. 23, No. 4, Fall 1997, pp.411-423.

# 2D.6
# Role of Recycling in Environmental Protection

"Even as we applaud the desirability of the recycling movement, it is nonetheless true that it has become a symbolic act of political correctness that in some cases convinces individuals, firms, interest groups, and government entities that they are doing *all they need to do* for the environment. In this sense, [recycling] can serve as somewhat of an "inoculation" against catching the fully virulent contagious form of environmentalism… Putting all faith and energies into recycling, since that de facto allows a full-scale embrace of the consumer society, might allow us to be lulled dangerously to sleep at a time when the appropriate action might be to adjust or cancel an action at the outset. The mindset which urges us to "go ahead and do it, and we'll simply recycle all materials" will be patently inadequate, even with the most comprehensive of recycling plans… In summary, **recycling is vitally important, but viewed in this manner it reminds us that it is merely a necessary but partial solution to the jigsaw puzzle of sustainability**."

Source: "Recycling in Theory and Practice", Chapter 5 in Reuniting Economy & Ecology in Sustainable Development, Russ Beaton & Chris Maser, Lewis Publishers, 1999, pp.73-84; http://www.chrismaser.com/bk-reesd.htm

# Appendices

- Appendices A&B: Exploratory X-Y Statistical Plot Graphs to Compare State & City MSW Recycling Infrastructure Indicators & Unit Costs
  - Appendix A: State Recycling Infrastructure (1 data set)
  - Appendix B: Municipal Recycling Infrastructure (2 data sets)
- Appendix C: Four Alternative Study Plan Options for this Assessment

# Appendices A & B: Exploratory X-Y Statistical Plots

- Recycling infrastructure indicators: The following graphs display X-Y data plots of recycling rates and recycling costs ($/ton), compared to recycling infrastructure indicators (e.g. coverage, participation) for states and municipalities:
  - Measures of population & population density served by recycling programs/facilities
  - Measures of land area & count of municipalities served
  - Recycling budgets
  - Measures of households served

- Indicator associations: Best-fit data curves are displayed for each X-Y plot to test "goodness-of-fit" between recycling rates/costs and infrastructure indicators, based on four alternative mathematical formulations (linear, logarithmic, exponential, power). Data curves are tests for degree of statistical associations, not for causality.

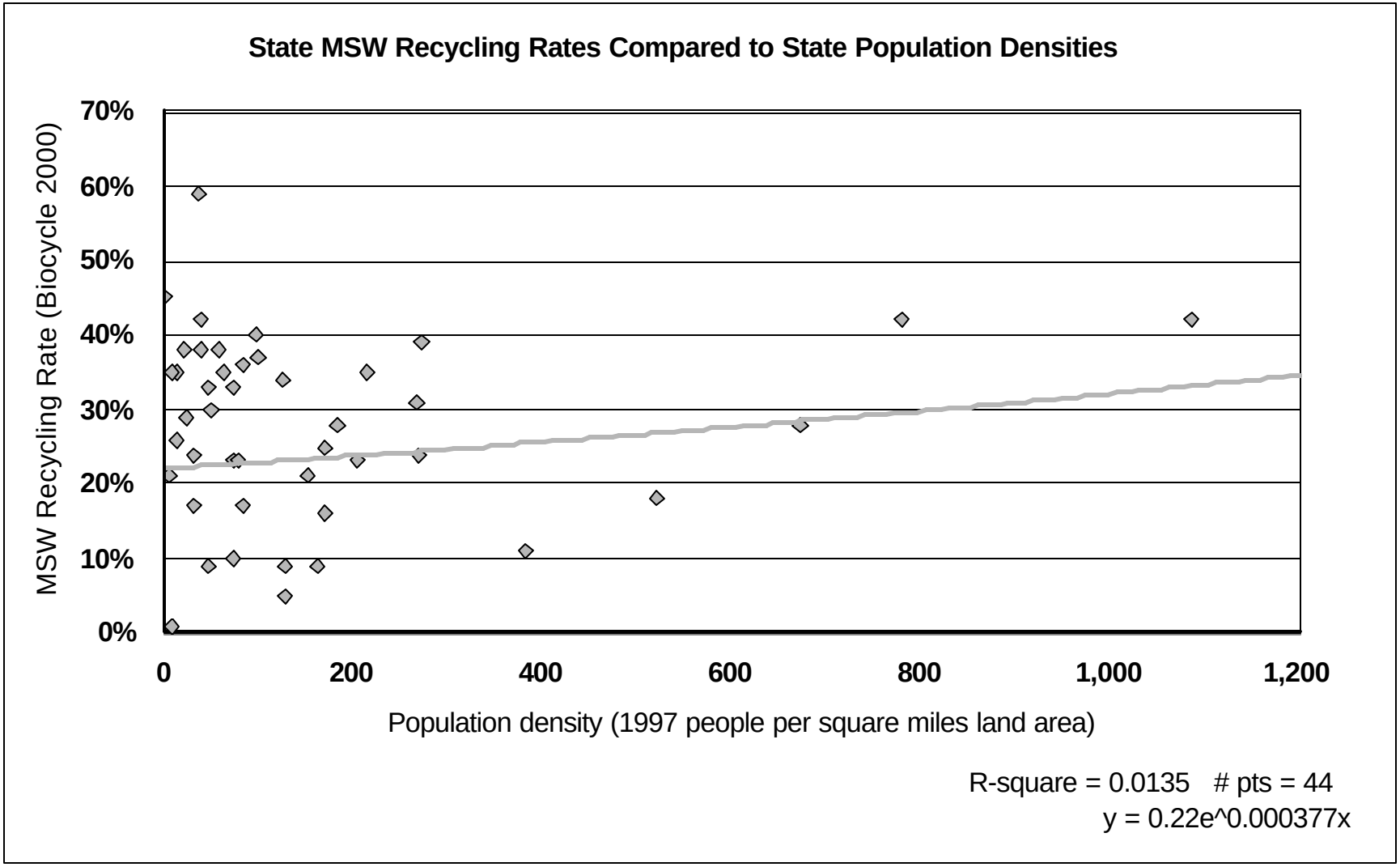
# Appendix A:
# State Recycling Rates & Infrastructure (exploratory X-Y plot graphs based on one data set)

# State MSW Recycling Database for Exploratory X-Y Plots

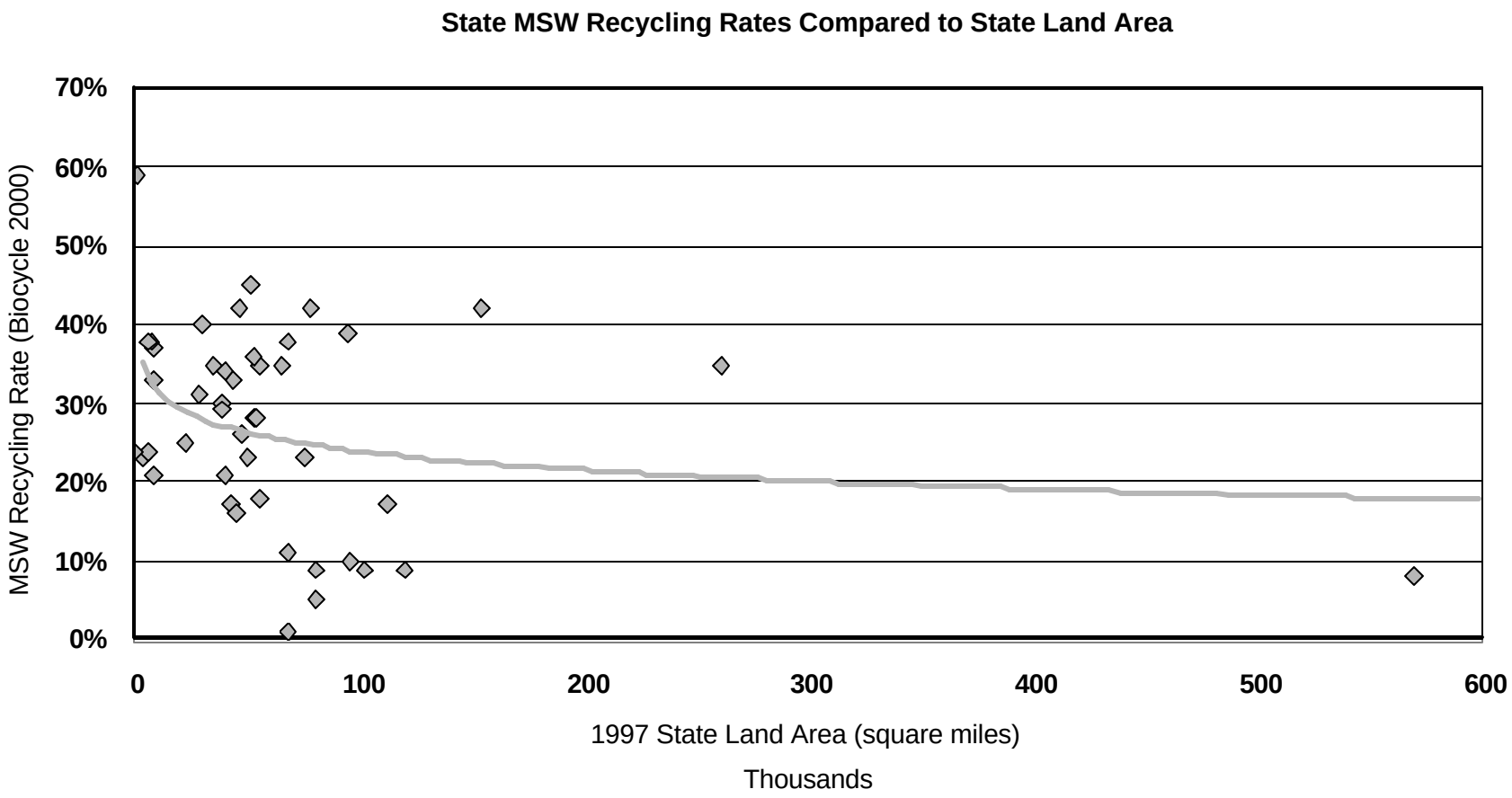
## State-By-State MSW Recycling Data Compared to State-wide Demographics

| | | A. MRF Statistics from 1997 Economic Census (NAICS 562920): | | | | | | | | | B. State-Wide MSW Recycling Data: | | | | | | | | C. State-Wide Recycling Penetration: | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | H | I (E/F) | J | K | L | M | N | O | P | Q | R | S (E/A) | T (F/A) | U (E/R) | V (F/R) | W (G/R) | X (H/R) | Y (M/E) |
| | | | | | | | | | | | EPA-OSW rate | BioCycle rate | | % popltn served by curbside recycling | State annual recycling budget | Per capita 1998 state budget | 1996-98 households in income | Worker annual pay | BioCycle curbside recycling programs | | | | | | | |
| | | MRF | MRF | MRF | MRF | | | State | Incorprtd | | State MSW | BioCycle | BioCycle | | | | poverty | mean | | State | State | State | State | State | State | State | State annual |
| | | establs | employees | payroll | revenues | 1997 State | land area | places | 2000 count | popltn density | recycling rate | recycling rate | MSW tons recycled | curbside recycling | budget capital for | | | | | popltn per MRF | sq.miles per MRF | population per curb- | land area er curbsid | places per curbside | households per curbside | recycling budget |
| Item | State | 1997 | 1997 | ($1000) | ($1000) | population | (sq.miles) | 1990 | households | 1997 | 1996 | 2000 | 2000 | 2000 | 2000 | environment | (% of popltn) | 2000 | 1999 | 1997 | 1997 | side progr | program | program | program | per capita |
| 0 | US total | 765 | 10,846 | 283,476 | 1,299,033 | 267,743,595 | 3,536,342 | 19,289 | 105,480,101 | 76 | | 32% | 409,029,000 | | $172,999,000 | | | | | 349,992 | 4,623 | | | | | $0.646 |
| 1 | Alabama | 8 | 50 | 750 | 4,480 | 4,322,113 | 50,750 | 439 | 1,737,080 | 85 | 20% | 23% | 4,500,000 | 25% | $250,000 | $41.45 | 14.7% | $29,041 | 38 | 540,264 | 6,344 | 113,740 | 1,336 | 12 | 45,713 | $0.058 |
| 2 | Alaska | 1 | 0 to 19 | Withheld | Withheld | 609,655 | 570,374 | 152 | 221,600 | 1 | 7% | 8% | 686,000 | 0% | $0 | $431.08 | 8.8% | $35,144 | 1 | 609,655 | | 609,655 | | | | $0 |
| 3 | Arizona | 12 | 171 | 4,208 | 16,667 | 4,553,249 | 113,642 | 86 | 1,901,327 | 40 | 14% | 17% | 5,750,000 | 47% | $2,260,000 | $33.37 | 18.1% | $32,610 | 32 | 379,437 | 9,470 | 142,289 | 3,551 | 3 | 59,416 | $0.496 |
| 4 | Arkansas | 5 | 37 | 692 | 2,929 | 2,523,186 | 52,075 | 487 | 1,042,696 | 48 | 36% | 45% | 2,056,000 | | $0 | $63.80 | 17.2% | $26,317 | 41 | 504,637 | 10,415 | 61,541 | 1,270 | 12 | 25,432 | $0 |
| 5 | California | 83 | 1,030 | 24,920 | 114,340 | 32,182,118 | 155,973 | 456 | 11,502,870 | 206 | 26% | 42% | 66,100,000 | 89% | $0 | $63.74 | 16.3% | $41,207 | 511 | 387,736 | 1,879 | 62,979 | 305 | 1 | 22,511 | $0 |
| 6 | Colorado | 11 | 500 to 999 | Withheld | Withheld | 3,892,029 | 103,730 | 267 | 1,658,238 | 38 | 17% | 9% | 6,535,000 | | $0 | $39.29 | 9.3% | $37,168 | 70 | 353,821 | 9,430 | 55,600 | 1,482 | 4 | 23,689 | $0 |
| 7 | Connecticut | 12 | 160 | 6,976 | 22,661 | 3,267,240 | 4,845 | 31 | 1,301,670 | 674 | 23% | 23% | 3,234,000 | 100% | $800,000 | $22.33 | 9.9% | $45,486 | 169 | 272,270 | 404 | 19,333 | 29 | 0 | 7,702 | $0.245 |
| 8 | Delaware | 4 | 0 to 19 | Withheld | Withheld | 735,143 | 1,955 | 57 | 298,736 | 376 | 21% | 59% | 2,065,000 | 1% | $4,000,000 | $57.29 | 9.5% | $36,535 | 3 | 183,786 | 489 | 245,048 | 652 | 19 | 99,579 | $5.441 |
| 9 | Florida | 47 | 913 | 23,128 | 92,485 | 14,677,181 | 53,997 | 390 | 6,337,929 | 272 | 40% | 28% | 24,800,000 | 57% | $2,722,000 | $71.60 | 13.9% | $30,560 | 315 | 312,280 | 1,149 | 46,594 | 171 | 1 | 20,120 | $0.185 |
| 10 | Georgia | 21 | 187 | 5,139 | 18,001 | 7,489,982 | 57,919 | 535 | 3,006,369 | 129 | 33% | | 10,236,000 | | $0 | $54.64 | 14.3% | $34,214 | 179 | 356,666 | 2,758 | 41,843 | 324 | 3 | 16,795 | $0 |
| 11 | Hawaii | 2 | 0 to 19 | Withheld | Withheld | 1,192,057 | 6,423 | 0 | 403,240 | 186 | 23% | 24% | 1,884,000 | 33% | $0 | $73.01 | 12.3% | $30,628 | 0 | 596,029 | 3,212 | | | | | $0 |
| 12 | Idaho | 1 | 0 to 19 | Withheld | Withheld | 1,208,865 | 82,751 | 200 | 469,645 | 15 | 10% | | 1,086,000 | | $0 | $95.83 | 13.2% | $27,701 | 6 | 1,208,865 | 82,751 | 201,478 | 13,792 | 33 | 78,274 | $0 |
| 13 | Illinois | 30 | 729 | 19,262 | 59,385 | 11,989,352 | 55,593 | 1,279 | 4,591,779 | 216 | 23% | 28% | 15,102,000 | 65% | $6,500,000 | $23.73 | 11.1% | $38,045 | 450 | 399,645 | 1,853 | 26,643 | 124 | 3 | 10,204 | $0.542 |
| 14 | Indiana | 12 | 66 | 2,321 | 12,828 | 5,864,847 | 35,870 | 566 | 2,336,306 | 164 | 23% | 35% | 13,571,000 | 73% | $3,160,000 | $28.44 | 8.6% | $31,030 | 169 | 488,737 | 2,989 | 34,703 | 212 | 3 | 13,824 | $0.539 |
| 15 | Iowa | 15 | 89 | 1,971 | 9,811 | 2,854,330 | 55,875 | 953 | 1,149,276 | 51 | 30% | 35% | 2,866,000 | 66% | $0 | $76.89 | 9.4% | $27,931 | 574 | 190,289 | 3,725 | 4,973 | 97 | 2 | 2,002 | $0 |
| 16 | Kansas | 8 | 0 to 19 | Withheld | Withheld | 2,601,437 | 81,823 | 627 | 1,037,891 | 32 | 11% | 9% | 3,000,000 | 46% | $1,500,000 | $60.12 | 10.1% | $29,361 | 101 | 325,180 | 10,228 | 25,757 | 810 | 6 | 10,276 | $0.577 |
| 17 | Kentucky | 7 | 218 | 6,505 | 18,110 | 3,910,366 | 39,732 | 438 | 1,590,647 | 98 | 18% | 30% | 4,376,000 | 15% | $150,000 | $61.49 | 15.5% | $28,800 | 43 | 558,624 | 5,676 | 90,939 | 924 | 10 | 36,992 | $0.038 |
| 18 | Louisiana | 8 | 203 | 4,981 | 23,031 | 4,353,646 | 43,566 | 301 | 1,656,053 | 100 | 15% | 17% | 3,361,000 | | $0 | $82.20 | 18.6% | $27,888 | 33 | 544,206 | 5,446 | 131,929 | 1,320 | 9 | 50,183 | $0 |
| 19 | Maine | 25 | 196 | 4,854 | 26,894 | 1,241,895 | 30,865 | 22 | 518,200 | 40 | 33% | 40% | 1,696,000 | 37% | $465,000 | $94.71 | 10.6% | $27,664 | 84 | 49,676 | 1,235 | 14,784 | 367 | 0 | 6,169 | $0.374 |
| 20 | Maryland | 10 | 124 | 4,204 | 24,012 | 5,094,924 | 9,775 | 155 | 1,980,859 | 521 | 27% | 37% | 6,268,000 | 70% | $0 | $59.70 | 8.6% | $36,395 | 100 | 509,492 | 978 | 50,949 | 98 | 2 | 19,809 | $0 |
| 21 | Massachus | 30 | 563 | 14,736 | 62,644 | 6,114,440 | 7,838 | 39 | 2,443,580 | 780 | 33% | 38% | 8,141,000 | 78% | $7,000,000 | $40.91 | 10.3% | $44,168 | 156 | 203,815 | 261 | 39,195 | 50 | 0 | 15,664 | $1.145 |
| 22 | Michigan | 32 | 174 | 6,216 | 26,355 | 9,779,984 | 56,809 | 534 | 3,785,661 | 172 | 25% | 18% | 18,717,000 | 30% | $260,000 | $38.40 | 10.8% | $37,011 | 200 | 305,625 | 1,775 | 48,900 | 284 | 3 | 18,928 | $0.027 |
| 23 | Minnesota | 21 | 494 | 16,188 | 76,753 | 4,687,408 | 79,617 | 854 | 1,895,127 | 59 | 46% | 42% | 5,634,000 | 75% | $14,000,000 | $83.90 | 9.9% | $35,414 | 771 | 223,210 | 3,791 | 6,080 | 103 | 1 | 2,458 | $2.987 |
| 24 | Mississippi | 4 | 51 | 338 | 1,735 | 2,731,644 | 46,914 | 295 | 1,046,434 | 58 | 12% | 16% | 4,400,000 | 12% | $500,000 | $69.26 | 18.3% | $25,208 | 15 | 682,911 | 11,729 | 182,110 | 3,128 | 20 | 69,762 | $0.183 |
| 25 | Missouri | 20 | 72 | 1,470 | 7,265 | 5,408,455 | 68,898 | 942 | 2,194,594 | 78 | 26% | 38% | 10,288,000 | | | $45.46 | 10.4% | $31,384 | 197 | 270,423 | 3,445 | 27,454 | 360 | 5 | 11,140 | |
| 26 | Montana | 2 | 0 to 19 | Withheld | Withheld | 878,730 | 145,556 | 128 | 358,667 | 6 | 5% | | 757,000 | | $0 | $168.31 | 16.4% | $24,272 | 6 | 439,365 | 72,778 | 146,455 | 24,259 | 21 | 59,778 | $0 |
| 27 | Nebraska | 3 | 20 to 99 | Withheld | Withheld | 1,657,009 | 76,878 | 535 | 666,184 | 22 | 26% | 23% | 1,848,000 | 29% | $4,000,000 | $81.79 | 10.8% | $27,693 | 15 | 552,336 | 25,626 | 110,467 | 5,125 | 36 | 44,412 | $2.414 |
| 28 | New Hamps | 10 | 43 | 1,026 | 4,382 | 1,172,140 | 8,969 | 13 | 474,606 | 131 | 20% | 21% | 1,068,000 | 41% | $350,000 | $27.70 | 8.4% | $34,736 | 38 | 117,214 | 897 | 30,846 | 236 | 0 | 12,490 | $0.299 |
| 29 | New Jersey | 33 | 464 | 10,585 | 51,234 | 8,058,384 | 7,419 | 320 | 3,064,645 | 1,086 | 43% | 38% | 9,200,000 | 90% | $11,300,000 | $37.36 | 9.0% | $43,676 | 510 | 244,193 | 225 | 15,801 | 15 | 1 | 6,009 | $1.402 |
| 30 | New Mexico | 5 | 26 | 531 | 3,076 | 1,723,965 | 121,365 | 98 | 677,971 | 14 | 12% | 9% | 3,418,000 | 21% | $0 | $49.12 | 22.4% | $27,498 | 3 | 344,793 | 24,273 | 574,655 | 40,455 | 33 | 225,990 | $0 |
| 31 | New York | 47 | 583 | 14,773 | 73,734 | 18,146,200 | 47,224 | 619 | 7,056,860 | 384 | 32% | 42% | 31,100,000 | 95% | $0 | $18.88 | 16.6% | $45,358 | 1472 | 386,089 | 1,005 | 12,328 | 32 | 0 | 4,794 | $0 |
| 32 | North Caroli | 22 | 690 | 15,373 | 73,177 | 7,430,675 | 48,718 | 511 | 3,132,013 | 153 | 22% | 26% | 13,500,000 | 46% | $1,300,000 | $59.89 | 12.5% | $31,068 | 271 | 337,758 | 2,214 | 27,419 | 180 | 2 | 11,557 | $0.175 |
| 33 | North Dakot | 3 | 20 to 99 | Withheld | Withheld | 640,965 | 68,994 | 366 | 257,152 | 9 | 27% | 11% | 573,000 | 16% | $50,000 | $130.32 | 13.2% | $24,683 | 25 | 213,655 | 22,998 | 25,639 | 2,760 | 15 | 10,286 | $0.078 |
| 34 | Ohio | 23 | 680 | 19,017 | 66,866 | 11,192,932 | 40,953 | 941 | 4,445,773 | 273 | 15% | 21% | 14,335,000 | | $0 | $27.56 | 11.6% | $32,508 | 372 | 486,649 | 1,781 | 30,089 | 110 | 3 | 11,951 | $0 |
| 35 | Oklahoma | 7 | 58 | 1,492 | 11,379 | 3,321,611 | 68,679 | 592 | 1,342,293 | 48 | 12% | 1% | 3,787,000 | 31% | $200,000 | $45.82 | 14.8% | $26,988 | 8 | 474,516 | 9,811 | 415,201 | 8,585 | 74 | 167,787 | $0.060 |
| 36 | Oregon | 9 | 164 | 2,255 | 13,062 | 3,243,272 | 96,003 | 241 | 1,333,723 | 34 | 29% | 39% | 4,544,000 | 77% | $815,000 | $80.56 | 12.8% | $32,776 | 122 | 360,364 | 10,667 | 26,584 | 787 | 2 | 10,932 | $0.251 |
| 37 | Pennsylvani | 30 | 268 | 6,129 | 27,012 | 12,011,278 | 44,820 | 1,022 | 4,777,003 | 268 | 20% | 33% | 11,620,000 | 72% | $74,085,000 | $42.10 | 11.3% | $34,015 | 879 | 400,376 | 1,494 | 13,665 | 51 | 1 | 5,435 | $6.168 |
| 38 | Rhode Islan | 3 | 20 to 99 | Withheld | Withheld | 987,263 | 1,045 | 8 | 408,424 | 945 | 23% | 24% | 1,561,000 | 85% | $0 | $38.19 | 11.8% | $32,615 | 26 | 329,088 | 348 | 37,972 | 40 | 0 | 15,709 | $0 |
| 39 | South Caroli | 8 | 65 | 2,594 | 14,742 | 3,788,119 | 30,111 | 270 | 1,533,854 | 126 | 27% | 31% | 4,483,000 | 42% | $5,051,000 | $48.30 | 13.3% | $28,179 | 186 | 473,515 | 3,764 | 20,366 | 162 | 1 | 8,247 | $1.333 |
| 40 | South Dako | 5 | 29 | 363 | 2,761 | 737,755 | 75,898 | 310 | 290,245 | 10 | 38% | | 514,000 | | $673,000 | $108.03 | 13.0% | $24,802 | 3 | 147,551 | 15,180 | 245,918 | 25,299 | 103 | 96,748 | $0.912 |
| 41 | Tennessee | 12 | 153 | 3,503 | 19,166 | 5,371,693 | 41,220 | 336 | 2,232,905 | 130 | 40% | 34% | 5,200,000 | | $0 | $32.58 | 14.5% | $30,557 | 35 | 447,641 | 3,435 | 153,477 | 1,178 | 10 | 63,797 | $0 |
| 42 | Texas | 44 | 529 | 9,458 | 57,773 | 19,385,699 | 261,914 | 1,171 | 7,393,354 | 74 | 14% | 35% | 44,791,000 | 25% | | $32.52 | 16.1% | $34,943 | 159 | 440,584 | 5,953 | 121,923 | 1,647 | 7 | 46,499 | |
| 43 | Utah | 1 | 20 to 99 | Withheld | Withheld | 2,065,001 | 82,168 | 228 | 701,281 | 25 | 19% | 5% | 2,433,000 | | $0 | $63.24 | 8.5% | $29,229 | 142 | 2,065,001 | 82,168 | 147,500 | 5,869 | 16 | 50,092 | $0 |
| 44 | Vermont | 1 | 0 to 19 | Withheld | Withheld | 588,632 | 9,249 | 51 | 240,634 | 64 | 30% | 33% | 578,000 | 55% | $366,000 | $108.63 | 10.6% | $28,914 | 80 | 588,632 | 9,249 | 7,358 | 116 | 1 | 3,008 | $0.622 |
| 45 | Virginia | 15 | 133 | 3,150 | 11,523 | 6,737,489 | 39,598 | 229 | 2,699,173 | 170 | 35% | 29% | 10,661,000 | 16% | $1,600,000 | $21.89 | 11.3% | $35,172 | 79 | 449,166 | 2,640 | 85,285 | 501 | 3 | 34,167 | $0.237 |
| 46 | Washington | 19 | 294 | 9,651 | 70,869 | 5,614,151 | 66,582 | 266 | 2,271,398 | 84 | 39% | 35% | 7,072,000 | 82% | $0 | $87.63 | 10.0% | $37,099 | 102 | 295,482 | 3,504 | 55,041 | 653 | 3 | 22,269 | $0 |
| 47 | West Virgini | 6 | 24 | 493 | 3,440 | 1,815,231 | 24,087 | 230 | 736,481 | 75 | 13% | 25% | 1,500,000 | | $1,300,000 | $77.61 | 17.6% | $26,888 | 75 | 302,539 | 4,015 | 24,203 | 321 | 3 | 9,820 | $0.716 |
| 48 | Wisconsin | 27 | 262 | 4,846 | 17,261 | 5,201,226 | 54,314 | 583 | 2,084,544 | 96 | 40% | 36% | 3,710,000 | 60% | $28,342,000 | $59.08 | 8.6% | $30,694 | 600 | 192,638 | 2,012 | 8,669 | 91 | 1 | 3,474 | $5.449 |
| 49 | Wyoming | 1 | 0 to 19 | Withheld | Withheld | 480,043 | 97,105 | 97 | 193,608 | 5 | 4% | 10% | 568,000 | 4% | $0 | $248.40 | 12.0% | $26,836 | 2 | 480,043 | 97,105 | 240,022 | 48,553 | 49 | 96,804 | $0 |
| Other not listed = | | | | | | | | | | | | | 3,856,000 | | | | | | | | | | | | | |

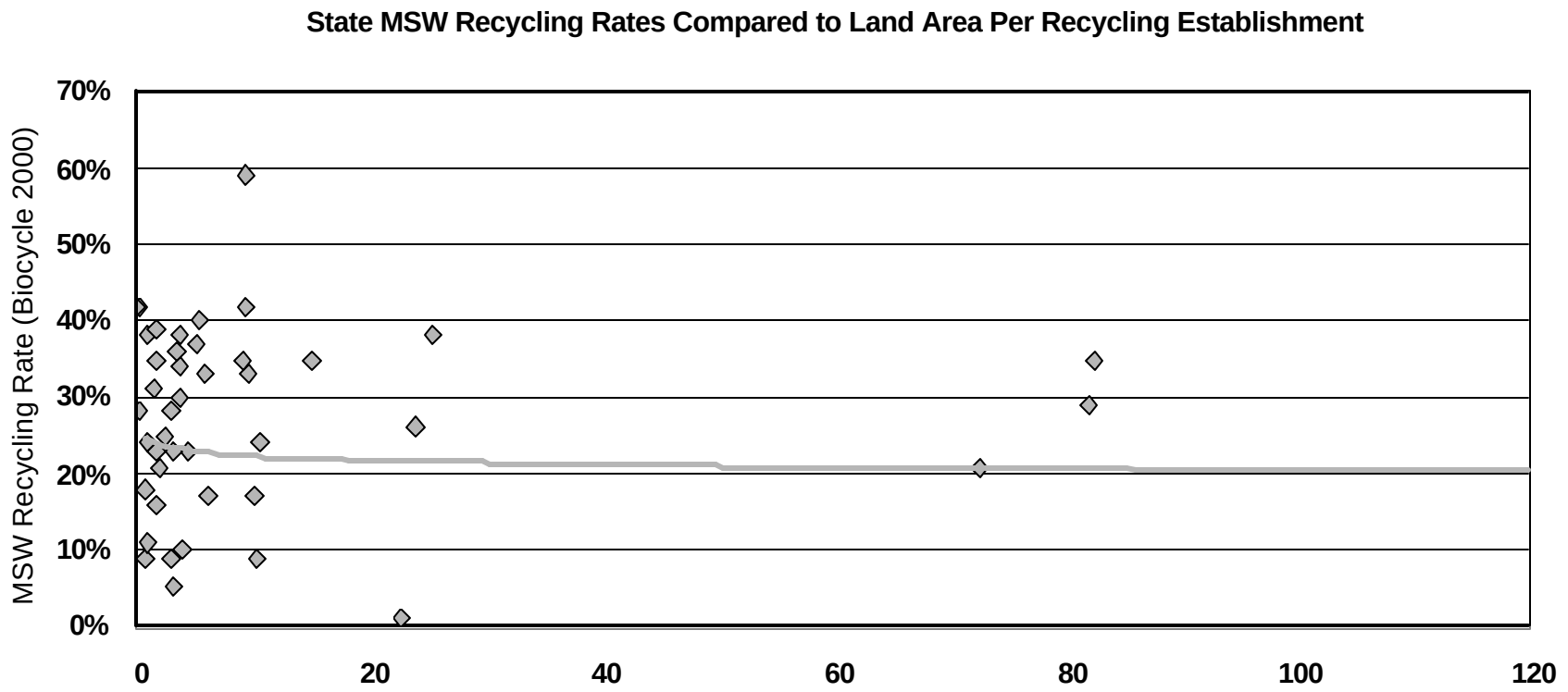
# State MSW Recycling Rates: Exploratory Scatter Plots



# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)

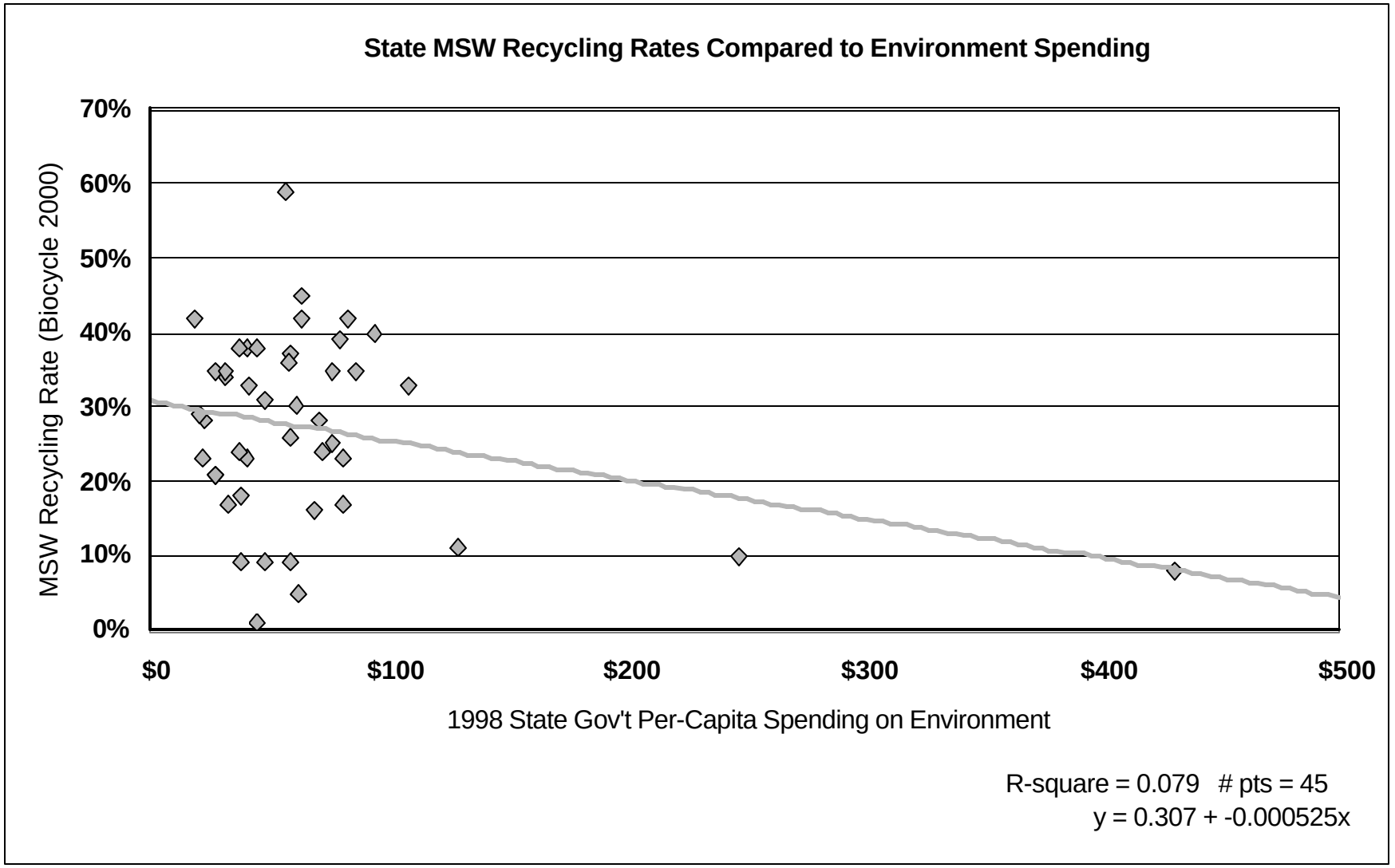



R-square = 0.00517 # pts = 43

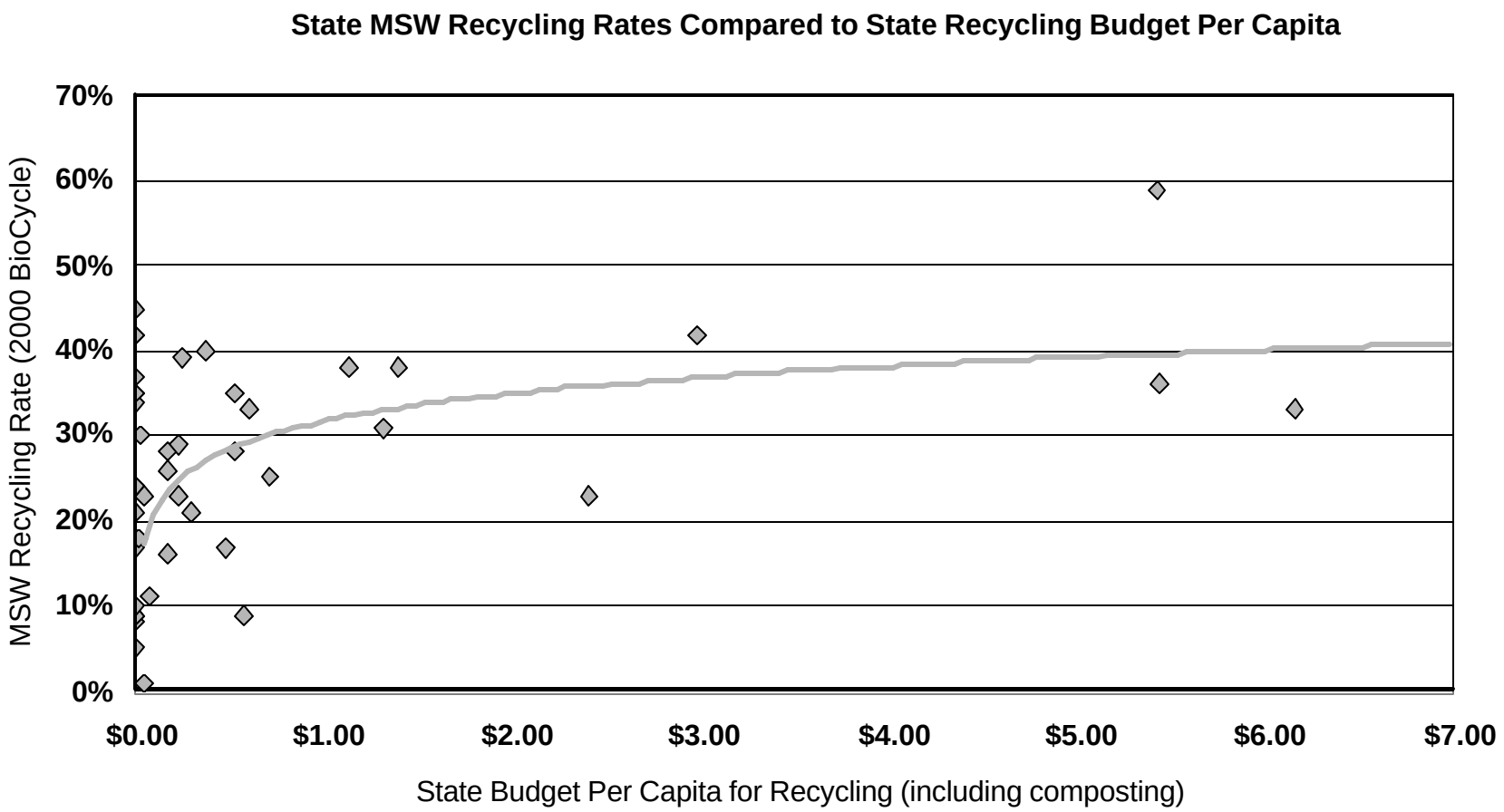
y = 0.316x^-0.0377

Data in this graph exclude Alaska (1 recycling establishment)

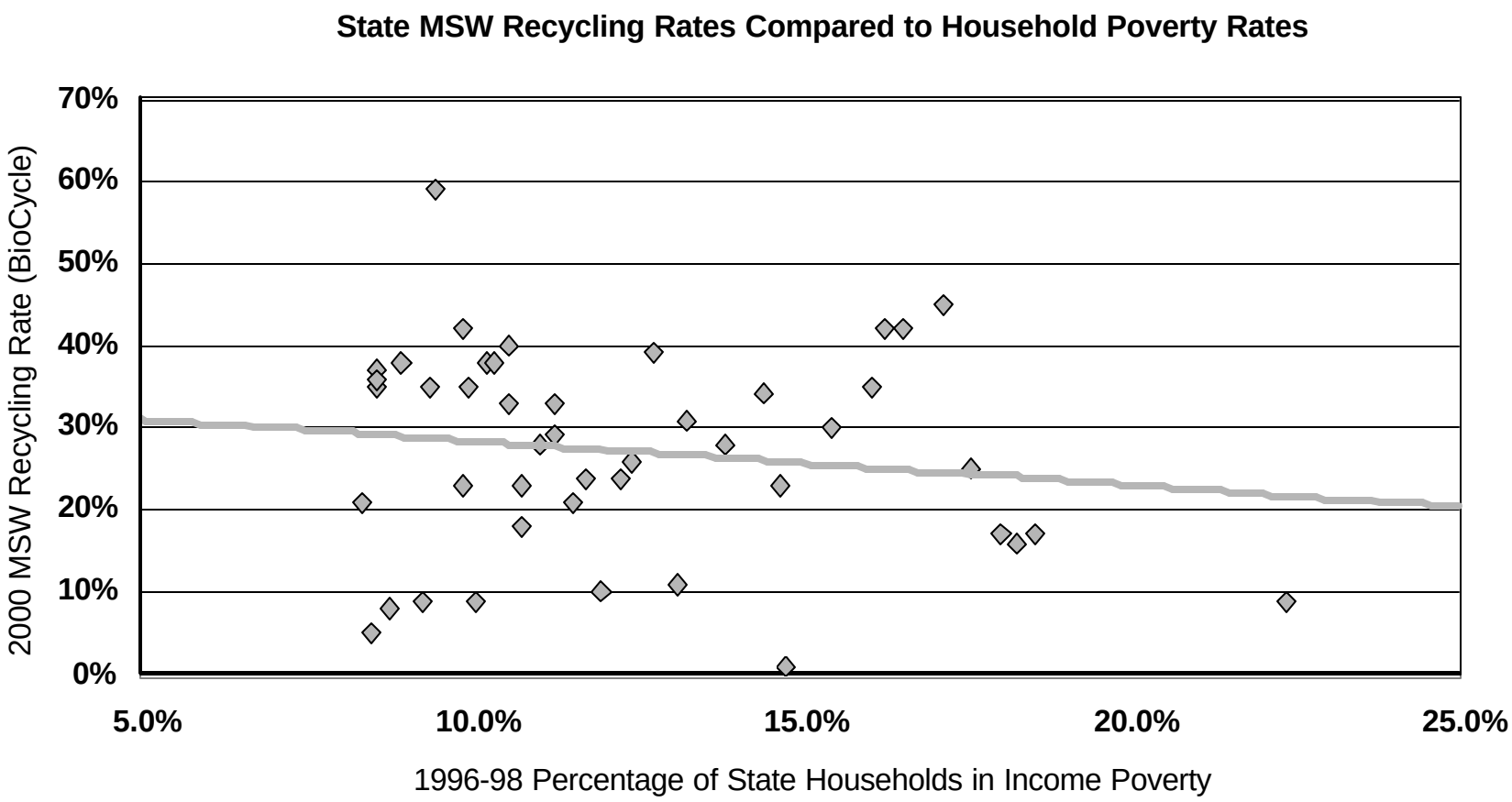
# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



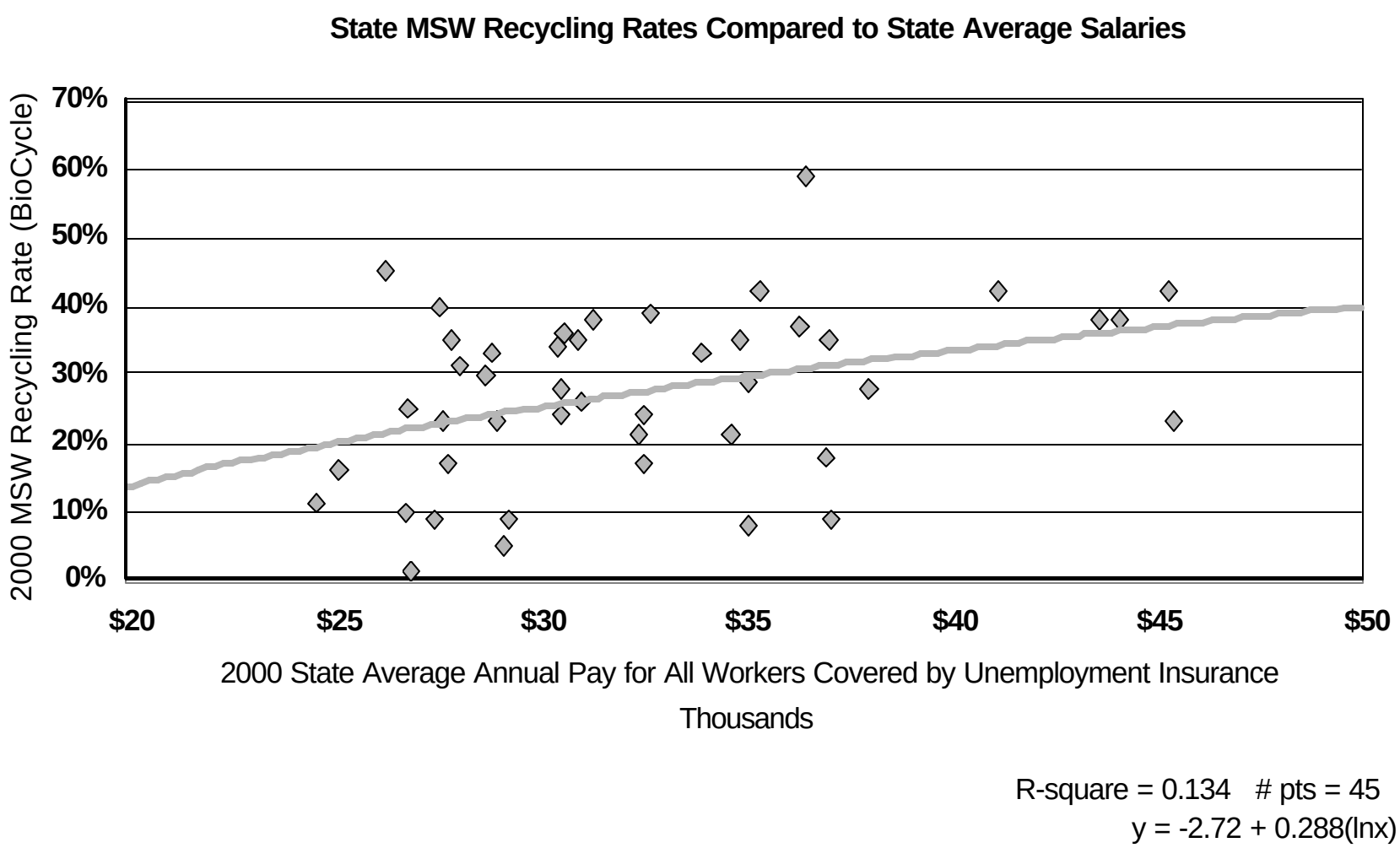
# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



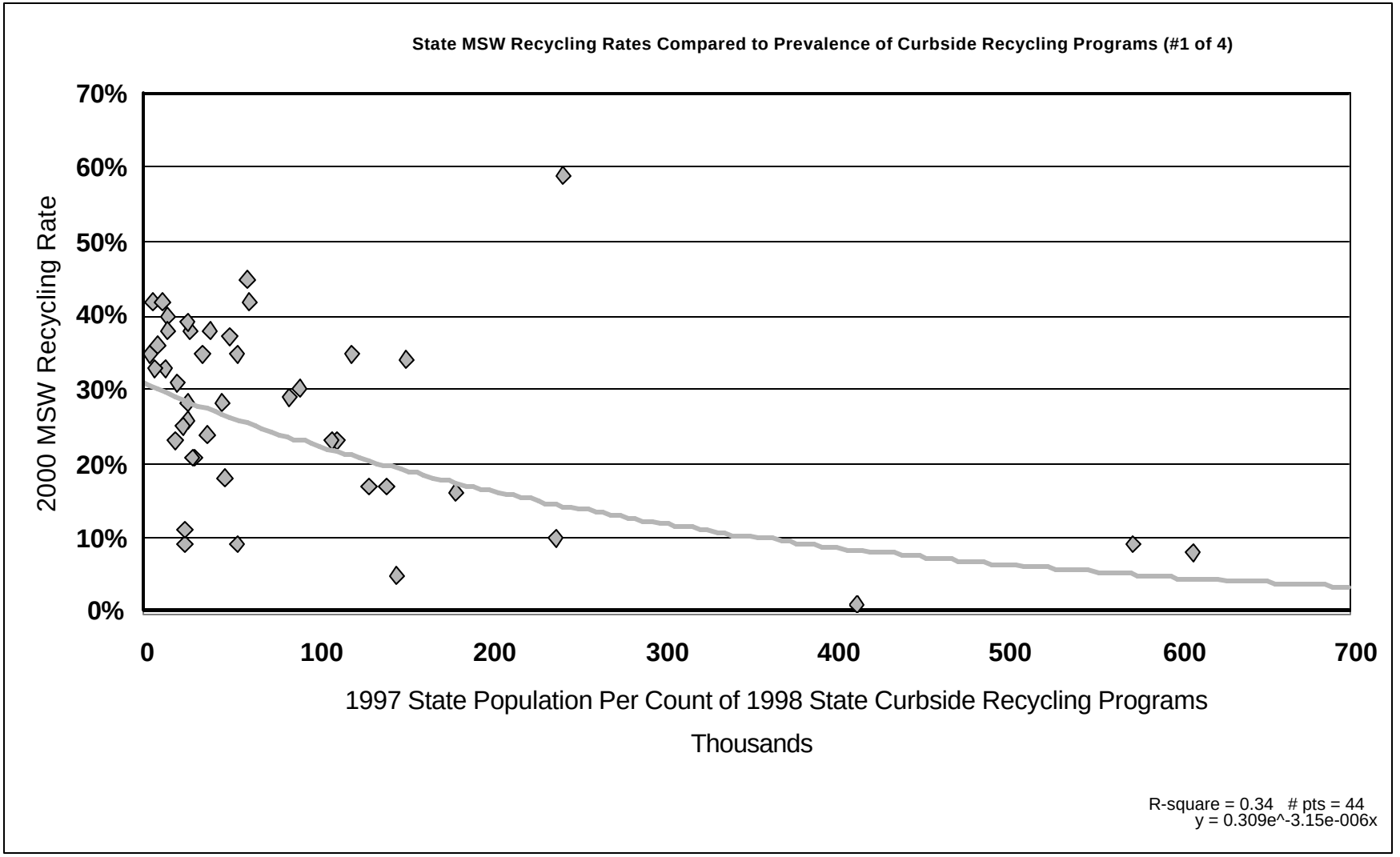
# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



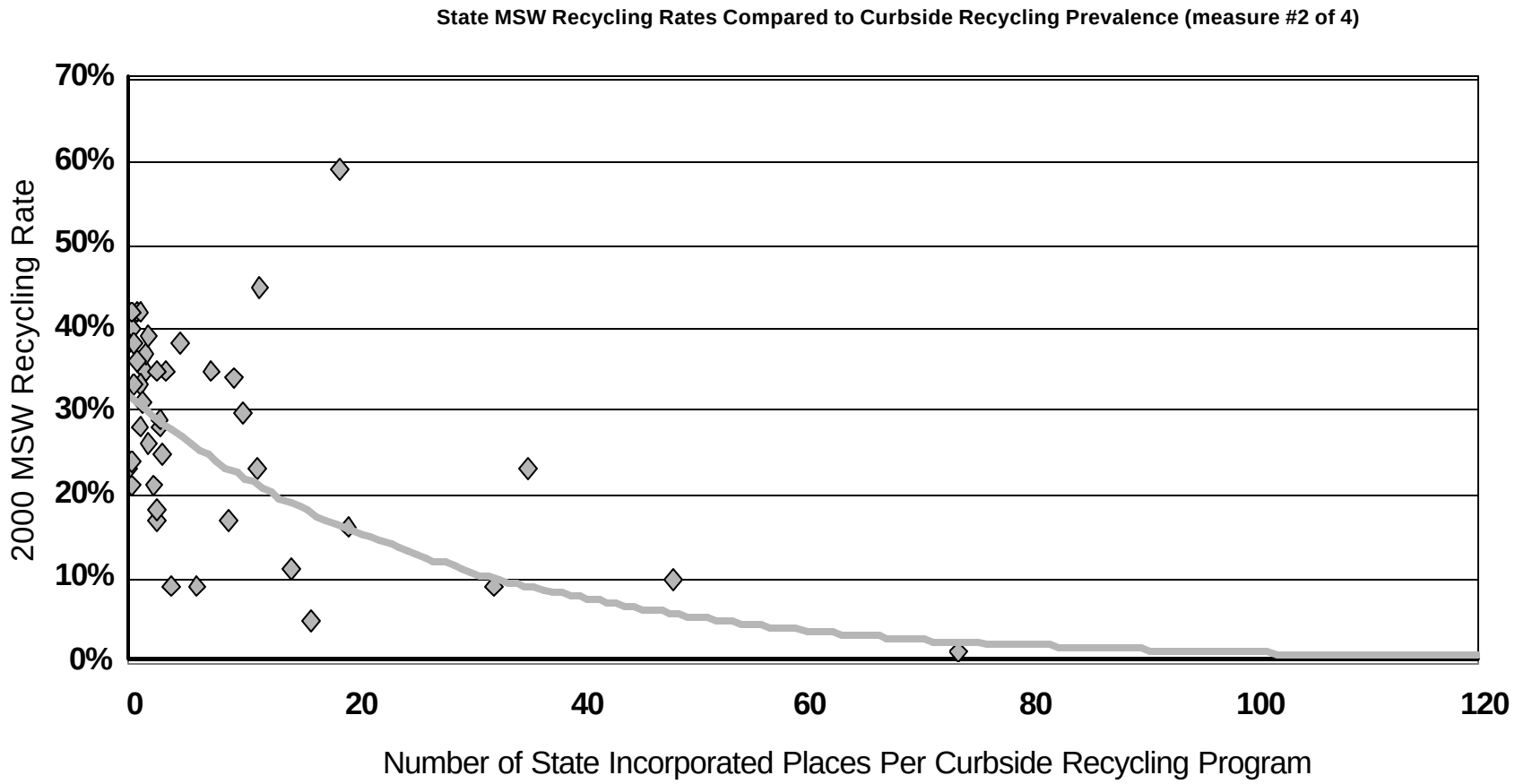
# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



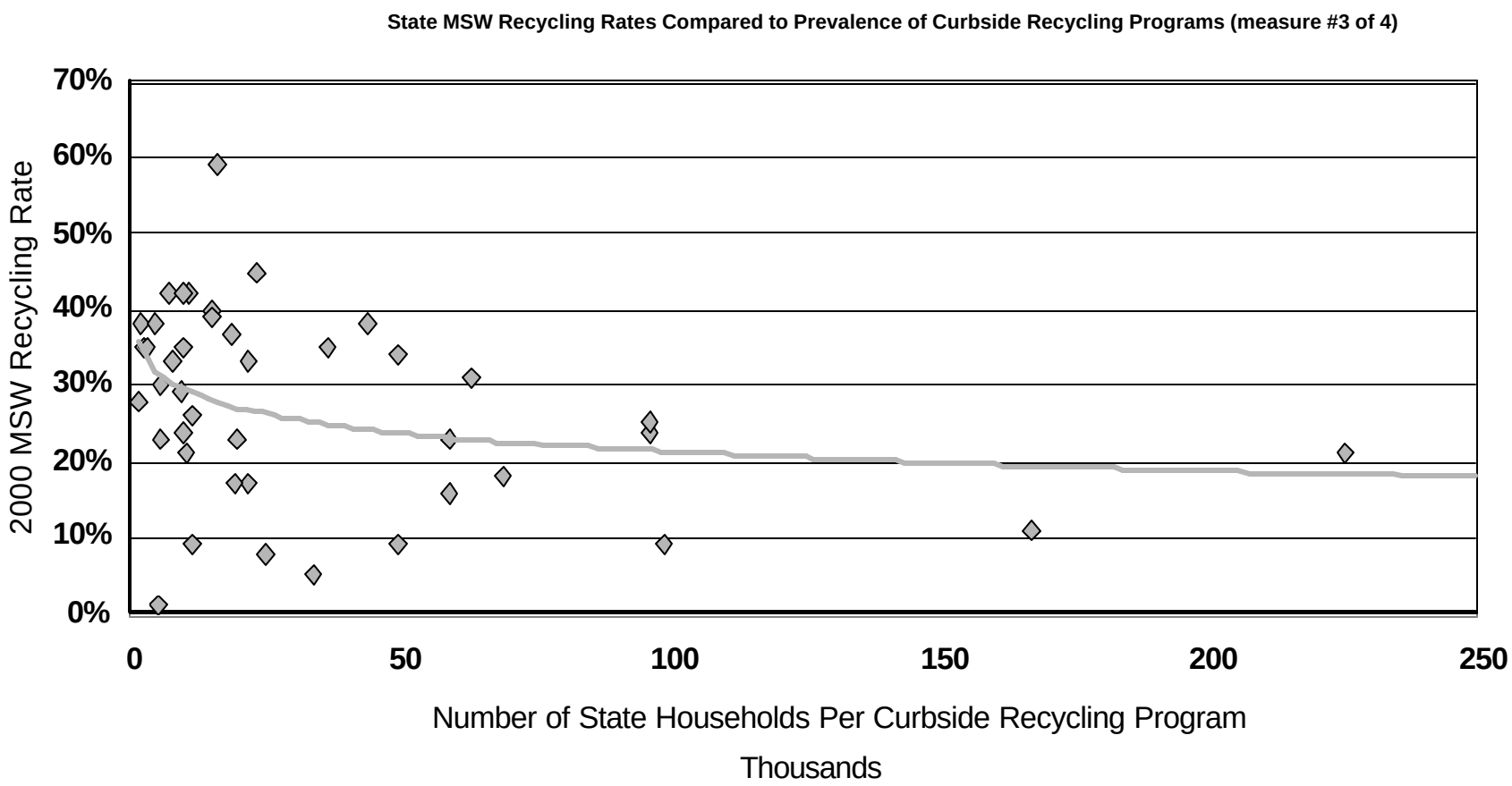
# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



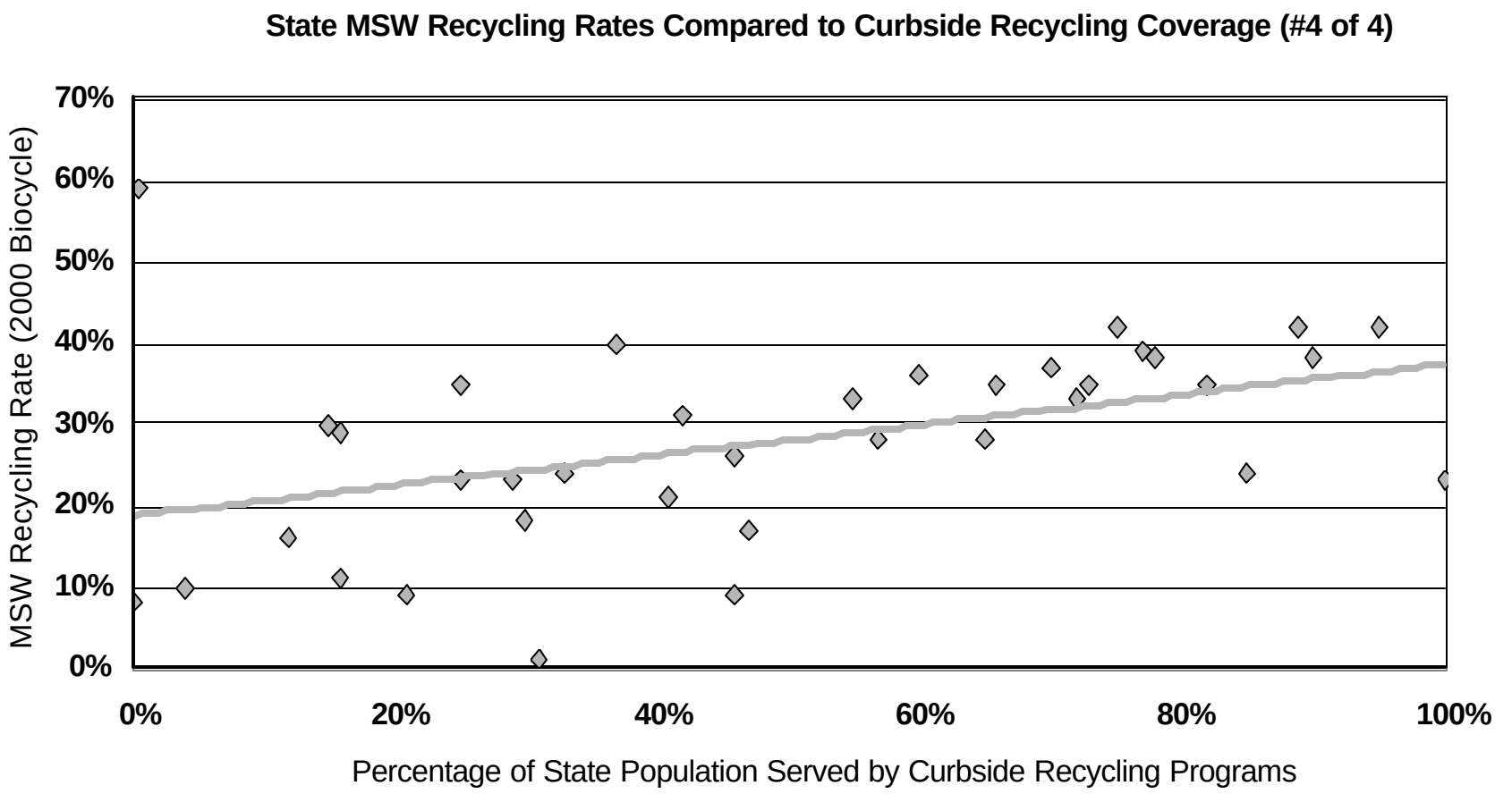
# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



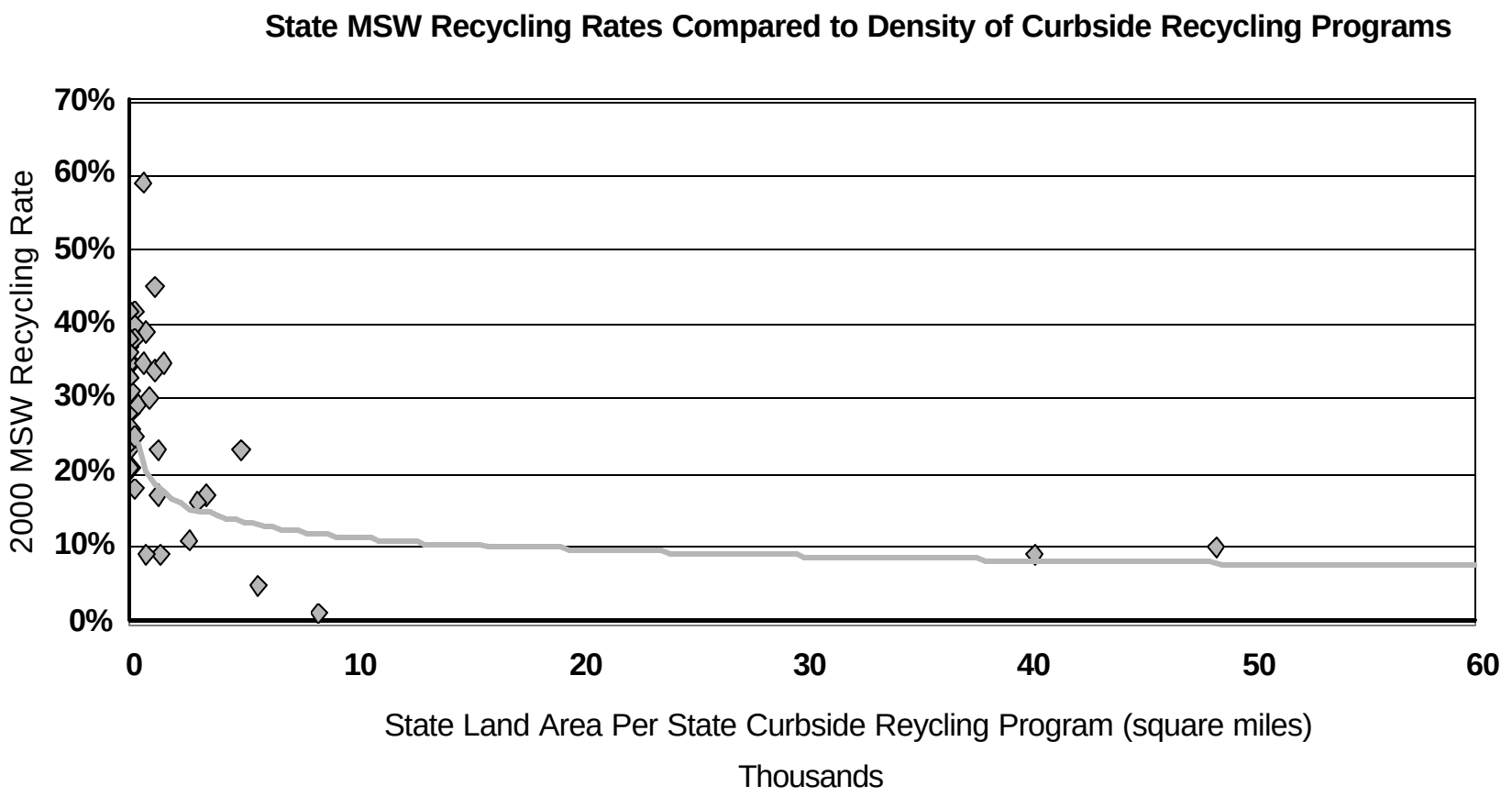
# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



# State MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



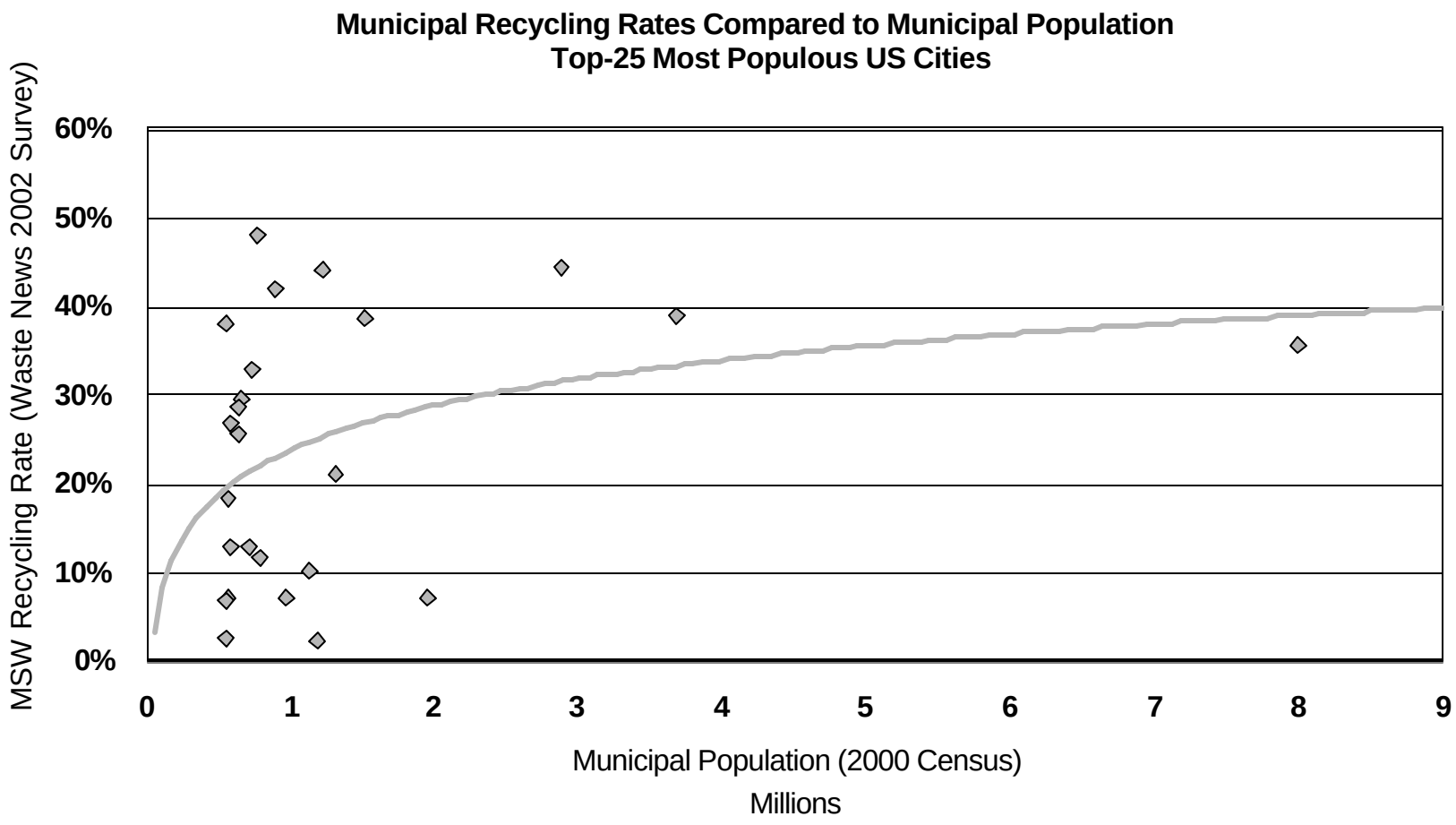
# Appendix B:
# Municipality Recycling Rates & Infrastructure
# (exploratory X-Y plot graphs based on two separate data sets)

# Municipality Recycling Dataset (Top-25 Most Populous Cities)

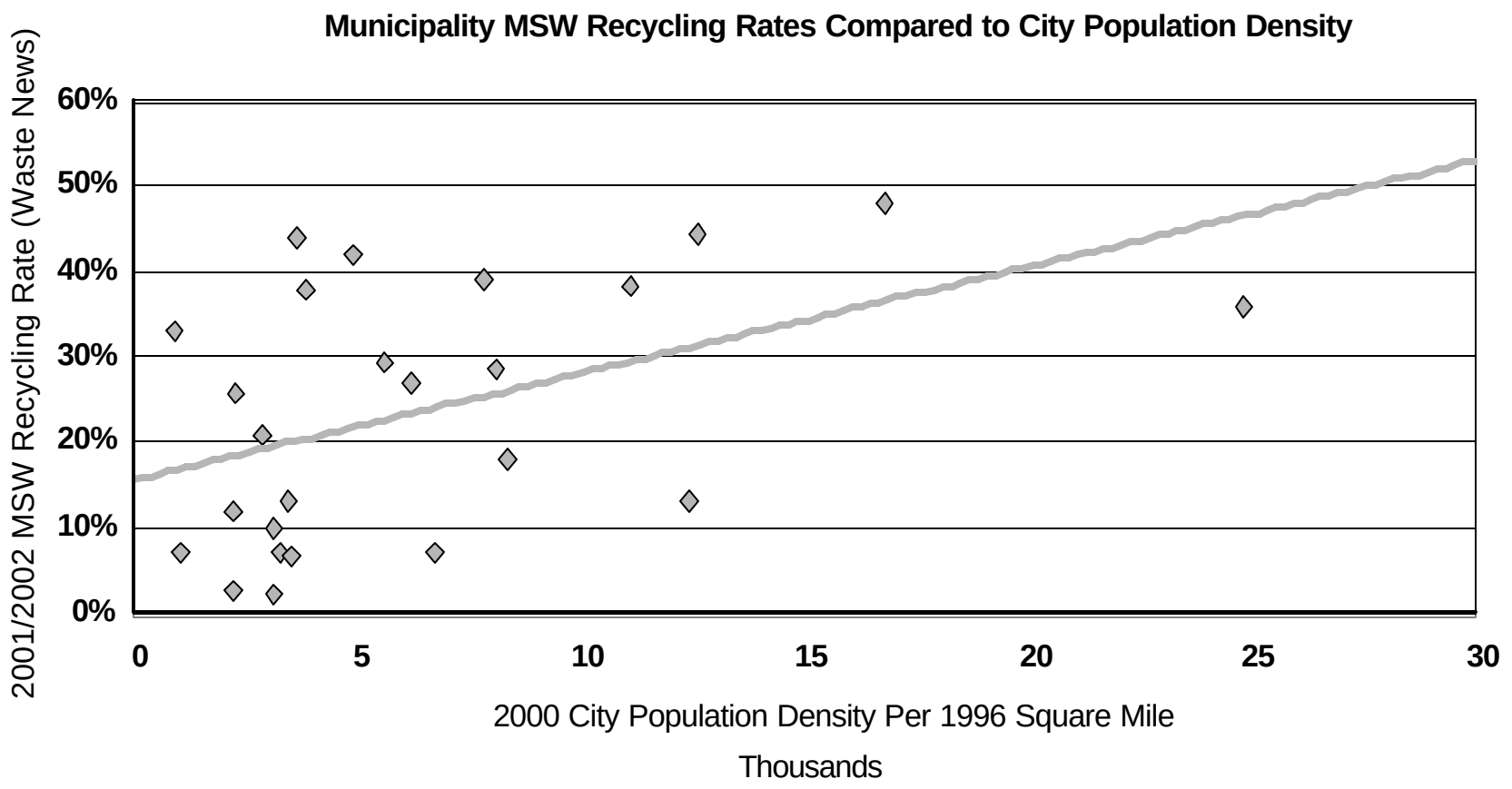
**Estimate of US National Average MSW Recycling Collection Cost & Recyclable Materials Revenues (source: Waste News 2003 Survey)**

| | | A | B | C | D (B/C) | E | F (B/E) | G (C/E) | H | I | J | K | L (J/K) | M | N (M/K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Waste News 2003 survey | | | | | | | | Recycling budget as | | | | | |
| | Top-25 most populous | MSW recyc rate for | City population | Land area (sq.miles) | Population | Nr. of dropoff | Population per drop off | Land area per drop off | Amount spent on recycling | % of solid waste | Recycling budget | Recycling volume | 2001/2002 recycling avg cost | Recycling materials revenue | Recycling revenue avg value |
| Item | municipalities | 2001/2002 | 2000 | 1996 | density | sites | sites | sites | per resident | budget | ($/year) | (tons/year) | ($/ton) | ($/year) | ($/ton) |
| 1 | San Francisc | 48.0% | 776,733 | 46.1 | 16,849 | 20 | 38,837 | 2 | $2.87 | | $2,231,988 | 825,000 | $3 | $10,603 | $0.01 |
| 2 | Chicago | 44.3% | 2,896,016 | 228.5 | 12,674 | 10 | 289,602 | 23 | | | | 2,146,321 | | $0 | $0 |
| 3 | San Diego | 44.0% | 1,223,400 | 330.7 | 3,699 | 55 | 22,244 | 6 | $15.04 | 23.4% | $18,400,000 | 98,270 | $187 | $1,858,363 | $18.91 |
| 4 | San Jose | 42.0% | 894,943 | 180.8 | 4,950 | | | | | | | 636,000 | | | |
| 5 | Los Angeles | 39.0% | 3,694,820 | 467.4 | 7,905 | 1 | 3,694,820 | 467 | $11.48 | 50.7% | $42,400,000 | 664,045 | $64 | $1,654,730 | $2.49 |
| 6 | Philadelphia | 38.5% | 1,517,550 | 136.0 | 11,158 | 3 | 505,850 | 45 | $5.34 | 9.3% | $8,100,000 | 38,551 | $210 | $94,830 | $2.46 |
| 7 | Seattle | 37.9% | 563,374 | 144.6 | 3,896 | 2 | 281,687 | 72 | | | | 43,919 | | | |
| 8 | New York | 35.7% | 8,008,278 | 321.8 | 24,886 | 4 | 2,002,070 | 80 | $12.92 | 9.9% | $103,438,905 | 5,960,496 | $17 | $5,960,778 | $1.00 |
| 9 | Jacksonville | 33.0% | 735,617 | 759.6 | 968 | | | | | | | 506,229 | | $1,600,000 | $3.16 |
| 10 | Austin | 29.5% | 656,562 | 116.0 | 5,660 | 1 | 656,562 | 116 | $7.75 | 12.6% | $5,090,621 | 51,726 | $98 | $1,388,220 | $26.84 |
| 11 | Baltimore | 28.7% | 651,154 | 80.3 | 8,109 | 6 | 108,526 | 13 | $1.36 | 1.5% | $887,148 | 29,475 | $30 | | |
| 12 | Milwaukee | 26.8% | 596,974 | 95.8 | 6,231 | 2 | 298,487 | 48 | $9.05 | 25.2% | $5,400,000 | 65,770 | $82 | | |
| 13 | Memphis | 25.6% | 650,100 | 277.0 | 2,347 | 3 | 216,700 | 92 | $2.00 | 3.0% | $1,300,000 | 104,087 | $12 | $366,988 | $3.53 |
| 14 | Phoenix | 21.0% | 1,321,045 | 456.7 | 2,893 | 3 | 440,348 | 152 | $3.47 | 9.4% | $4,583,286 | 111,521 | $41 | $4,200,000 | $37.66 |
| 15 | Wash DC | 18.2% | 572,059 | 68.3 | 8,382 | 1 | 572,059 | 68 | $6.44 | | $3,683,509 | 27,360 | $135 | $15,942 | $0.58 |
| 16 | Columbus | 13.0% | 711,470 | 203.3 | 3,500 | 49 | 14,520 | 4 | $2.95 | 6.4% | $2,100,840 | 51,605 | $41 | | |
| 17 | Boston | 13.0% | 589,141 | 47.2 | 12,482 | 1 | 589,141 | 47 | $5.94 | 9.2% | $3,500,000 | 38,100 | $92 | $165,000 | $4.33 |
| 18 | Indianapolis | 11.8% | 791,926 | 352.0 | 2,250 | 27 | 29,331 | 13 | $1.50 | 3.1% | $1,188,000 | 34,456 | $34 | $1,511 | $0.04 |
| 19 | San Antonio | 10.1% | 1,144,646 | 360.0 | 3,180 | 3 | 381,549 | 120 | $3.38 | 20.4% | $3,863,405 | 46,037 | $84 | $600,525 | $13.04 |
| 20 | Detroit | 7.2% | 970,196 | 143.0 | 6,785 | 1 | 970,196 | 143 | | | | 42,649 | | | |
| 21 | Nashville | 7.0% | 569,891 | 533.0 | 1,069 | 12 | 47,491 | 44 | $14.79 | 25.8% | $8,429,863 | | | $200,000 | |
| 22 | Houston | 7.0% | 1,953,631 | 594.0 | 3,289 | 12 | 162,803 | 50 | $2.05 | 6.7% | $4,000,000 | 32,144 | $124 | $550,000 | $17.11 |
| 23 | Denver | 6.7% | 554,636 | 154.6 | 3,588 | | | | $3.59 | 10.1% | $1,991,792 | 16,534 | $120 | $735,000 | $44.45 |
| 24 | El Paso | 2.5% | 563,662 | 247.4 | 2,278 | 15 | 37,577 | 16 | $2.13 | 5.1% | $1,201,229 | 7,191 | $167 | $230,796 | $32.10 |
| 25 | Dallas | 2.2% | 1,188,580 | 378.0 | 3,144 | 39 | 30,476 | 10 | $2.04 | 4.8% | $2,426,604 | 14,033 | $173 | | |
| | Mean = | 23.7% | | | 6,487 | | 517,767 | 74 | $5.80 | 13.1% | | Mean = | $90 | | $12.22 |
| | Median = | 25.6% | | | 3,896 | | 285,644 | 48 | $3.53 | 9.4% | | Median = | $84 | | $3.53 |
| | Pop-wtd avg = | 28.7% | | | | | | | | | | Tons-wtd avg = | $19 | | $1.68 |
| | Data points = | 25 | | | 25 | 22 | 22 | 22 | 20 | 18 | 20 | 24 | 19 | 18 | 17 |

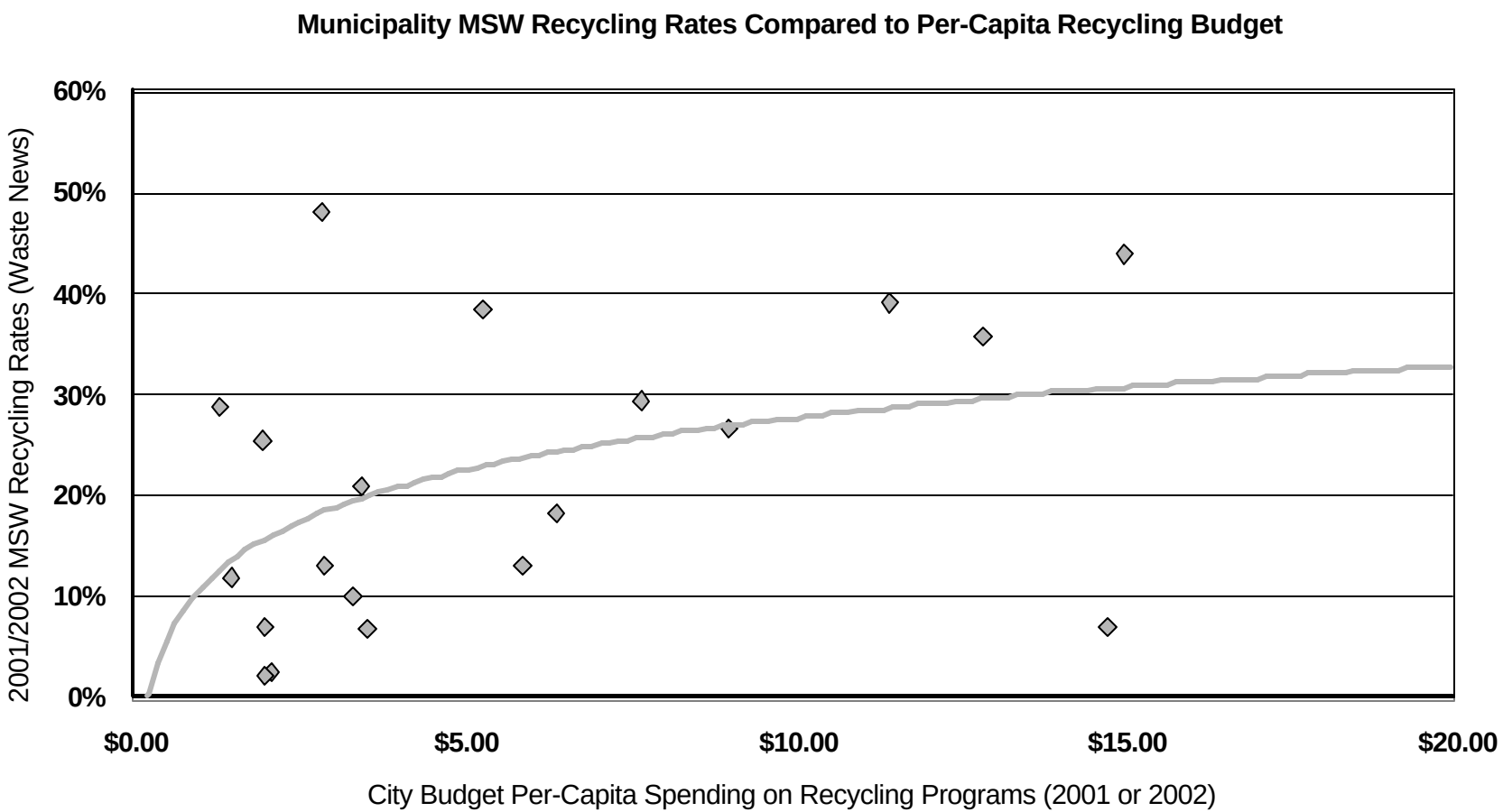
# Municipality MSW Recycling Rates: Exploratory Scatter Plots



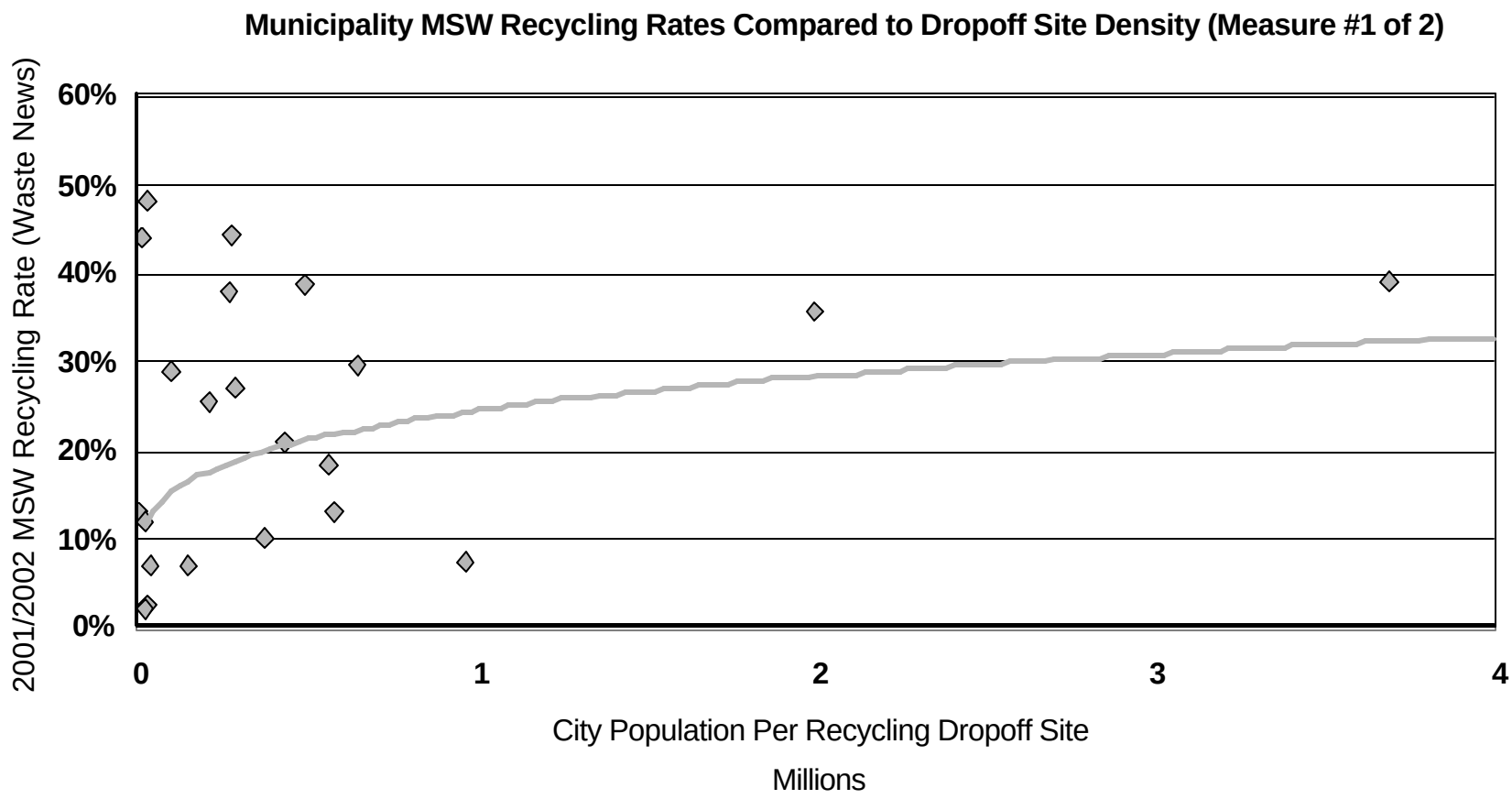
# Municipality MSW Recycling Rates: Exploratory Scatter Plots



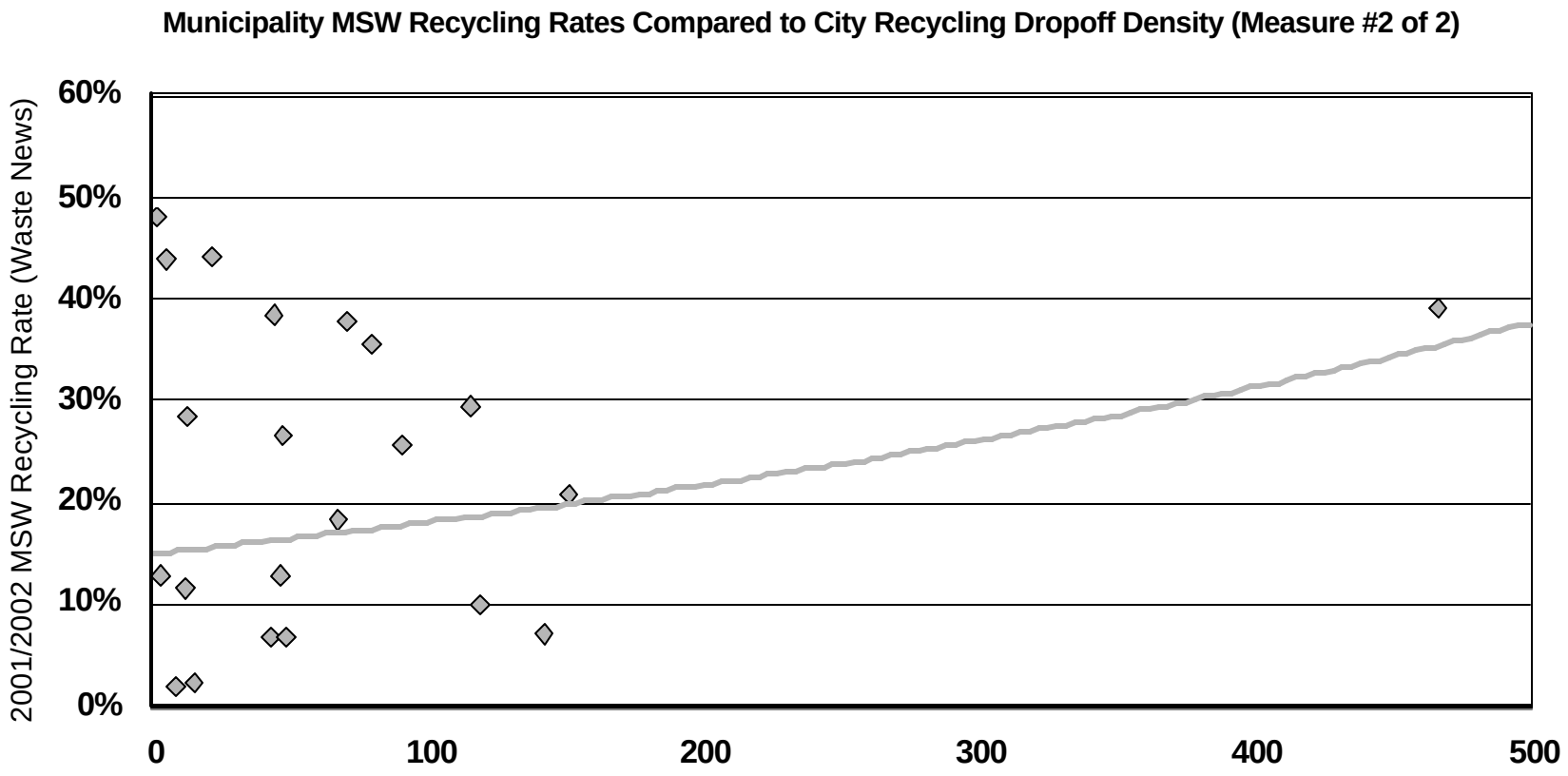
# Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



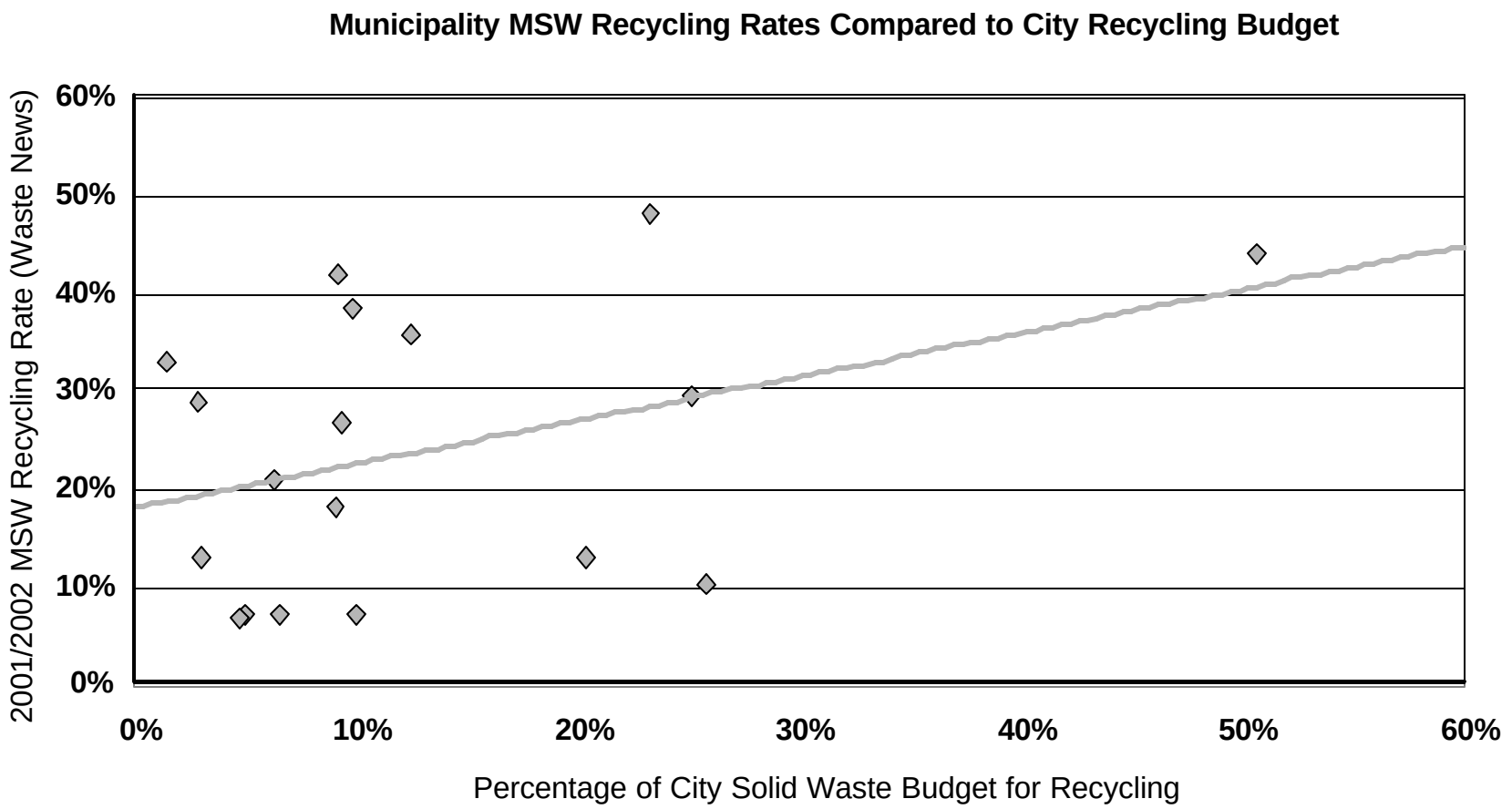
# Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



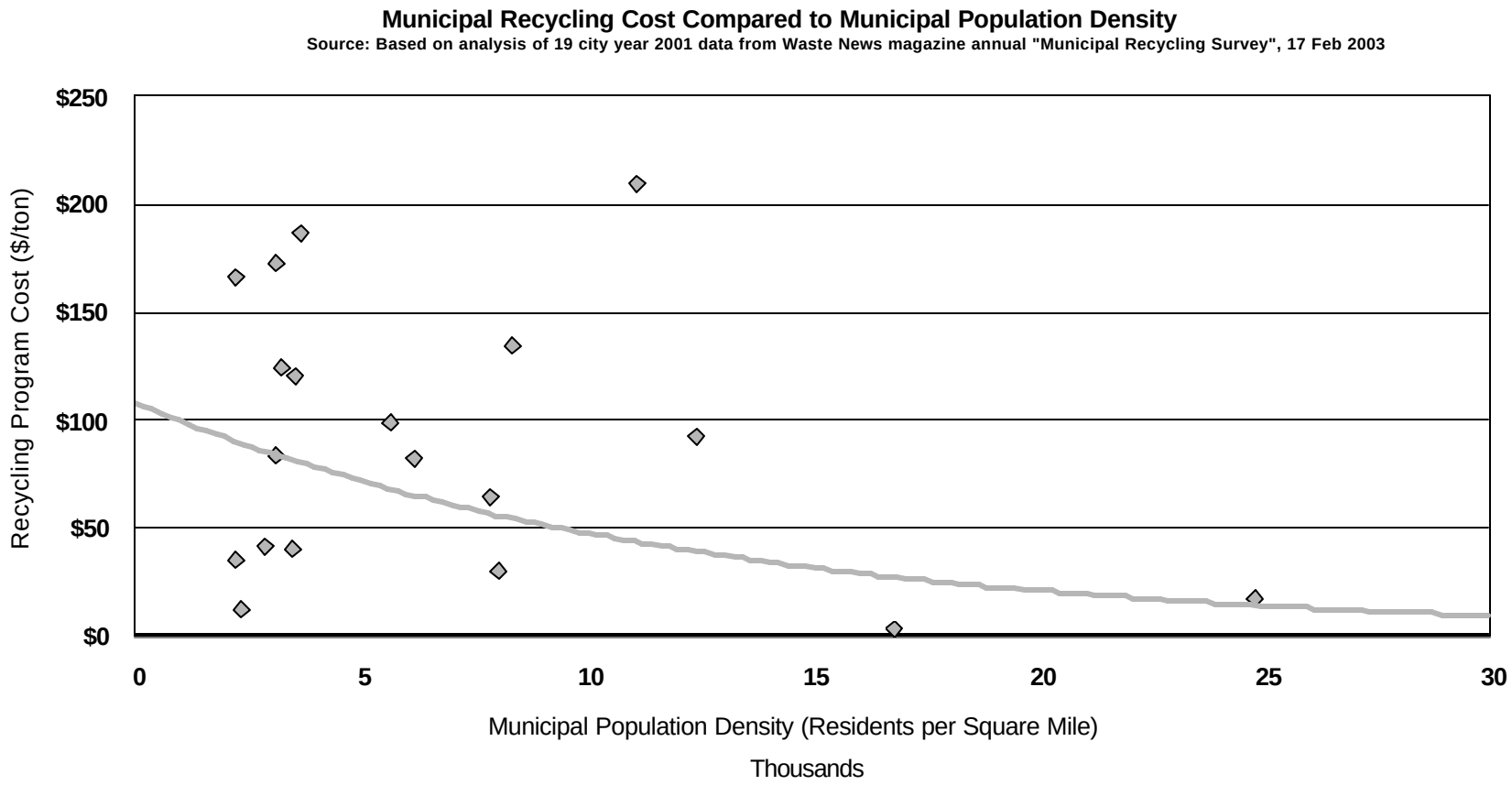
# Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



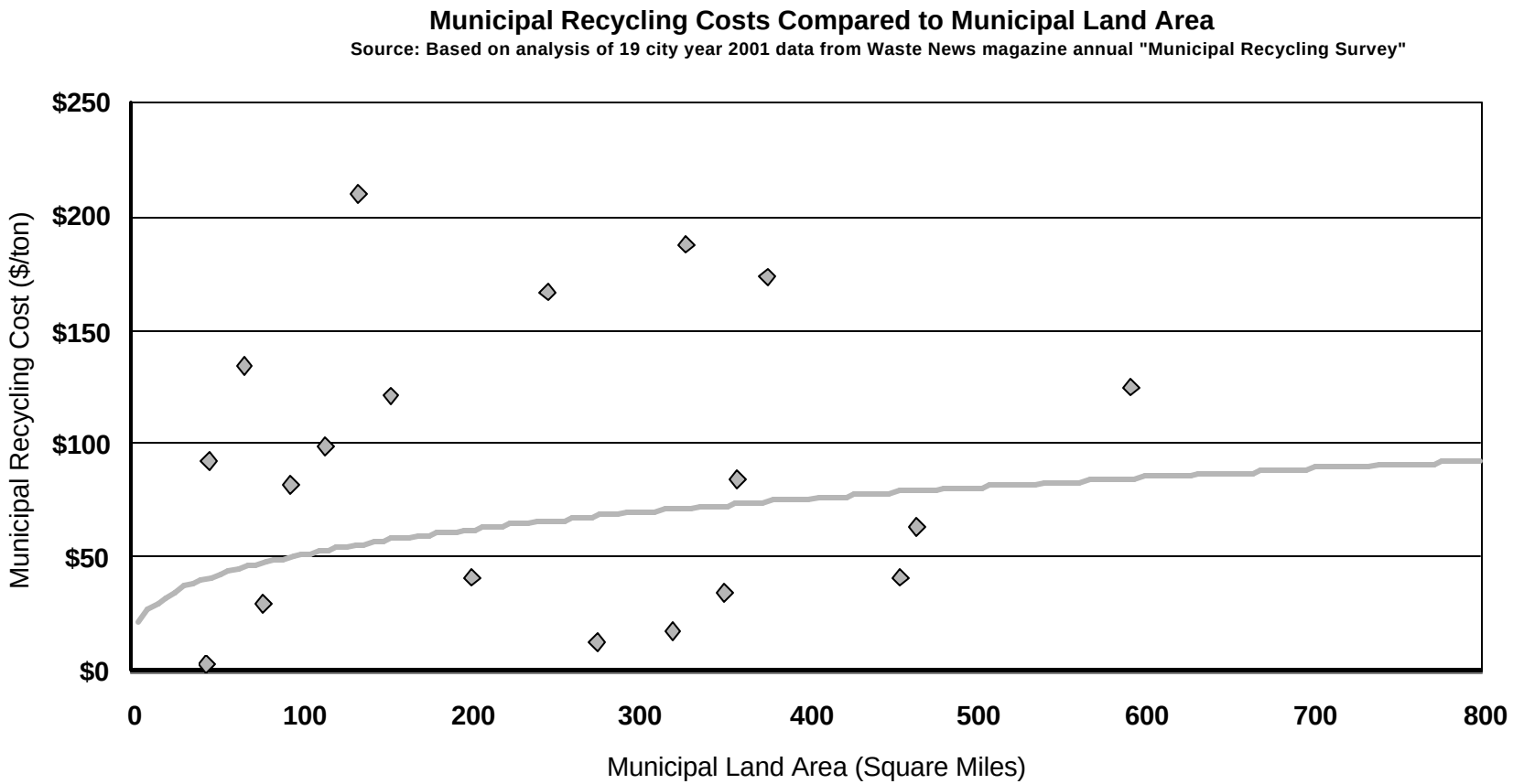
# Municipality MSW Recycling Rates: Exploratory Scatter Plots (cont'd)



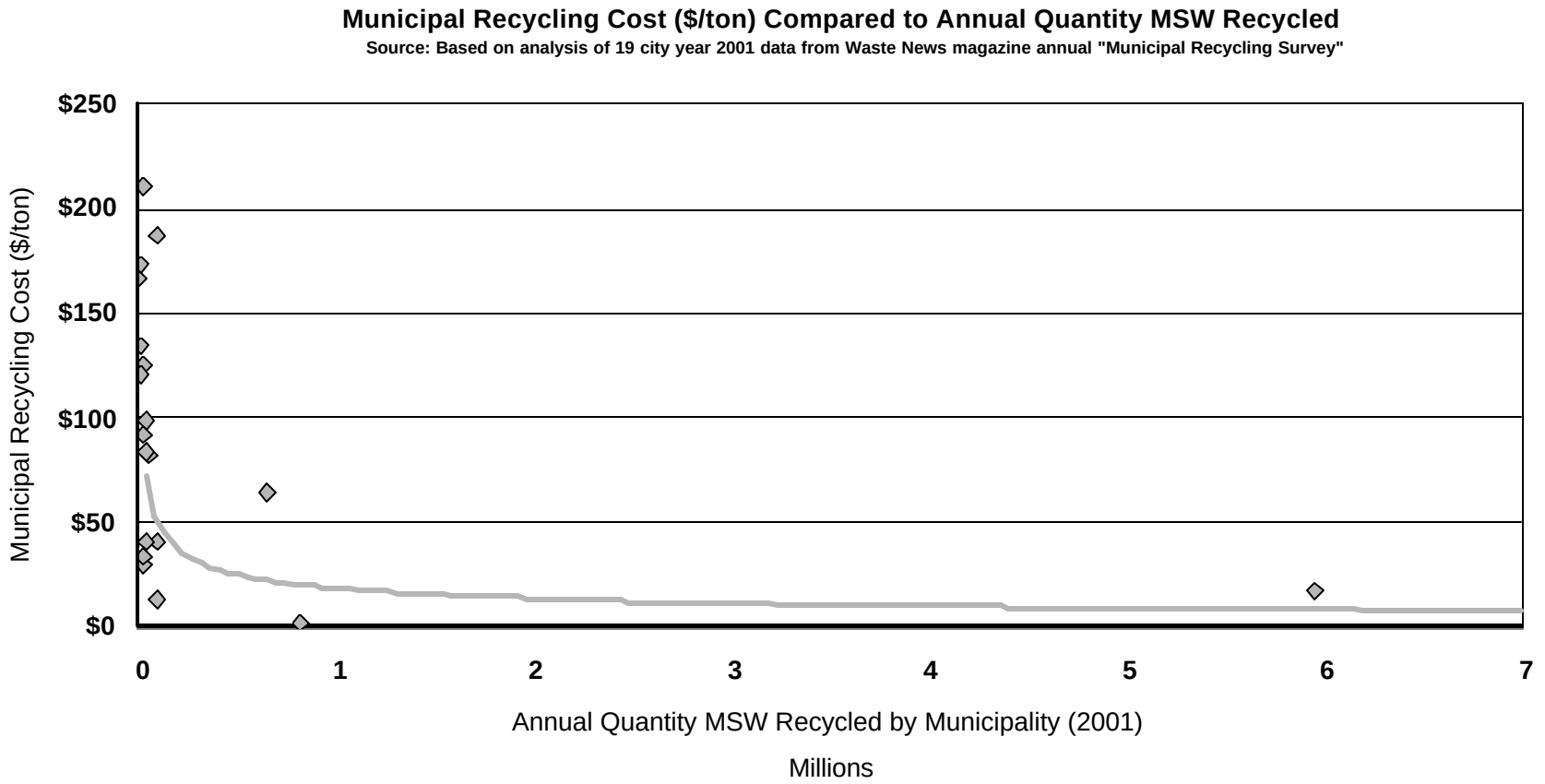
# Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Population Density (n=19 municipality sample 2001)



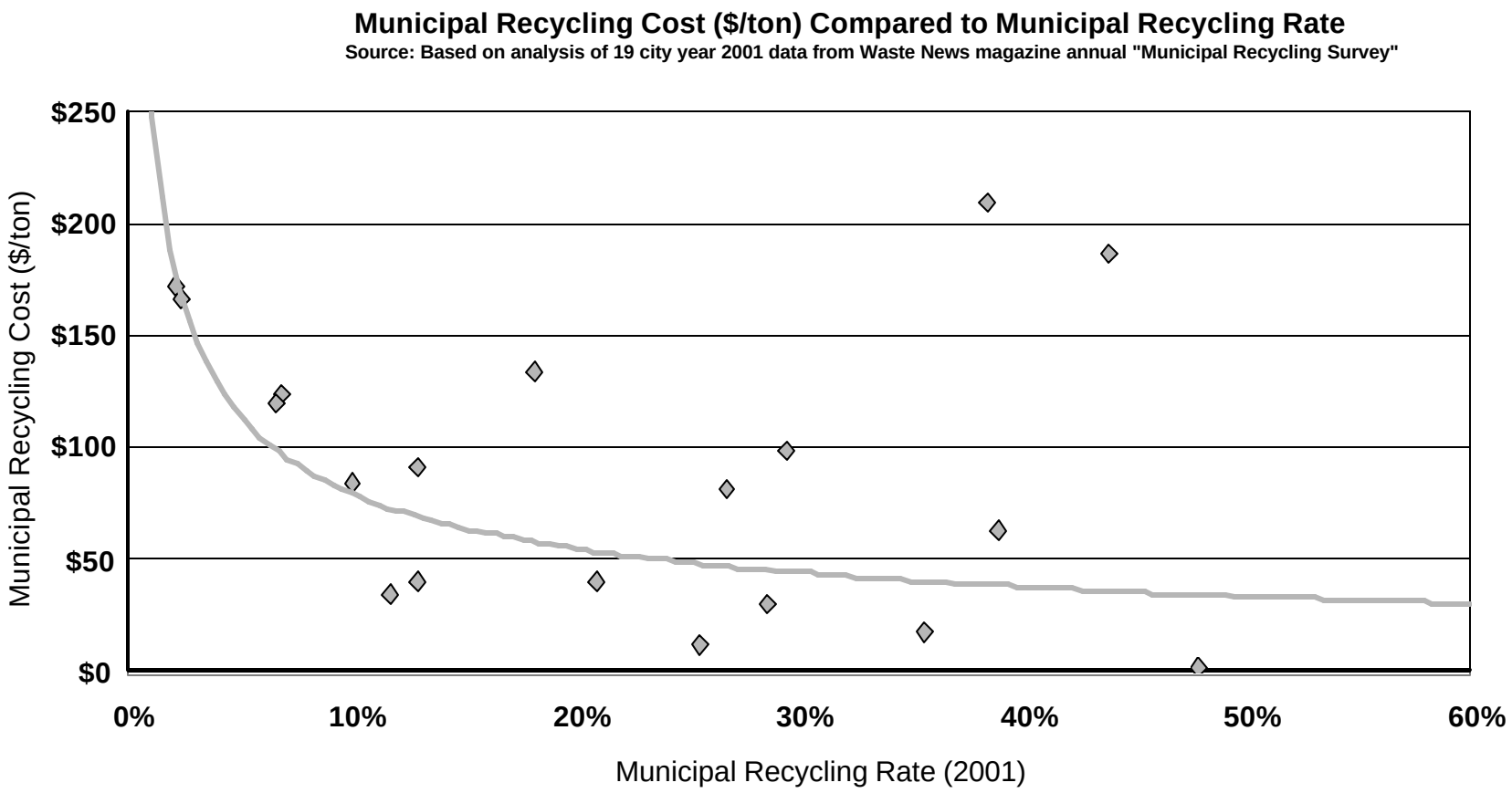
# Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Land Area (n=19 municipality sample 2001)



# Exploratory Comparison Between Average Recycling Cost ($/ton) & Annual Quantity Recycled (n=19 municipality sample 2001)



# Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Recycling Rate (n=19 municipality sample 2001)

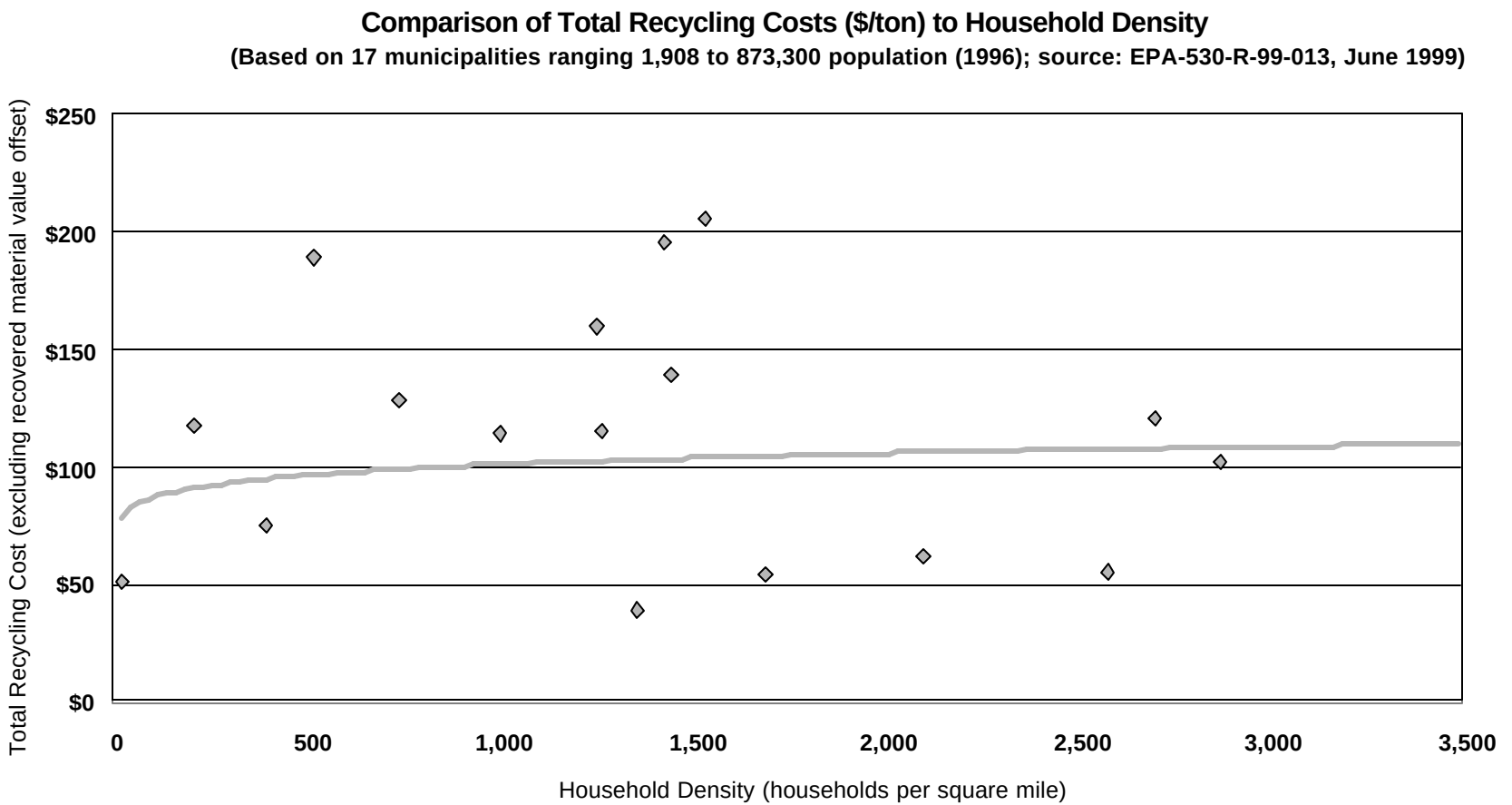


# 17 City Dataset from 1999 USEPA Study

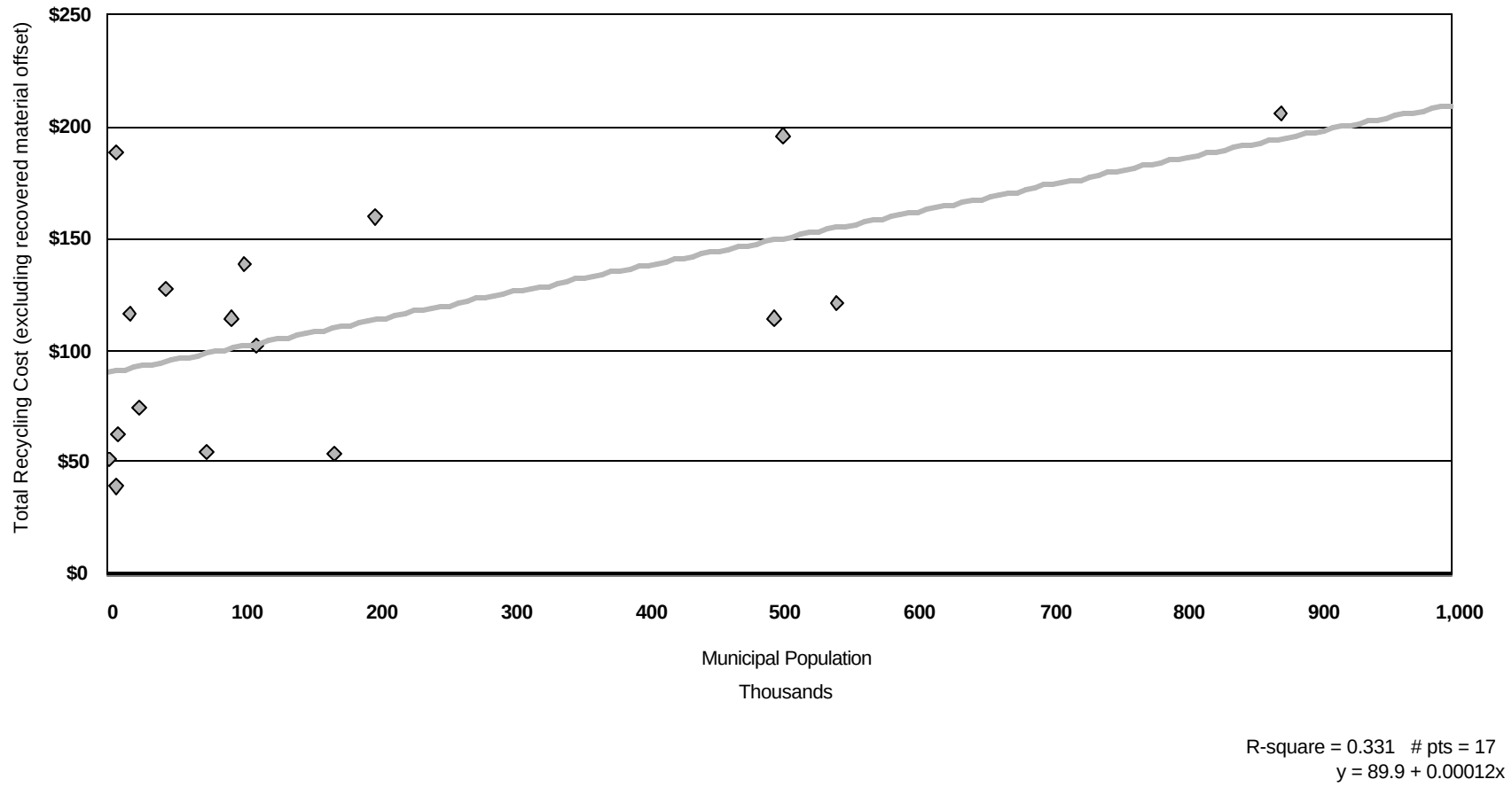
**17 Cities in MSW Recycling Cost Dataset from EPA-530-R-99-013, June 1999 (1996$)**

| | | | A | B | C | D | E (F-C-D) | F | G | H (F-G) |
|---|---|---|---|---|---|---|---|---|---|---|
| Item | City | State | 1996 population | Household density (per sq.mile) | Recycling collection ($/ton) | Recycling processing ($/ton) | Recycling admin/OH ($/ton) | Recycling total cost ($/ton) | Materials revenues ($/ton) | Recycling net cost ($/ton) |
| 1 | Ann Arbor | MI | 112,000 | 2,875 | $73 | $14 | $15 | $101.85 | $9.07 | $93 |
| 2 | Bellevue | WA | 103,700 | 1,451 | | | $10 | $139.13 | $0 | $139 |
| 3 | Chatham | NJ | 8,007 | 1,363 | | | $1 | $38.72 | $7.98 | $31 |
| 4 | Clifton | NJ | 75,000 | 2,583 | $46 | $1 | $8 | $54.61 | $4.81 | $50 |
| 5 | Crockett | TX | 8,300 | 523 | $14 | $100 | $75 | $188.91 | $17.01 | $172 |
| 6 | Dover | NH | 25,042 | 400 | | | $8 | $75.00 | $0 | $75 |
| 7 | Falls Church | VA | 10,000 | 2,108 | | | $21 | $62.00 | $0 | $62 |
| 8 | Fitchburg | WI | 17,266 | 216 | | | $36 | $117.00 | $0 | $117 |
| 9 | Leverett | MA | 1,908 | 28 | $7 | $0 | $44 | $51.29 | $16.99 | $34 |
| 10 | Loveland | CO | 44,300 | 744 | $112 | $0 | $16 | $128.00 | $10.61 | $117 |
| 11 | Madison | WI | 200,920 | 1,257 | $115 | $42 | $3 | $160.10 | $12.65 | $147 |
| 12 | Portland | OR | 503,000 | 1,437 | | | $72 | $196.00 | $14.64 | $181 |
| 13 | St. Paul | MN | 496,068 | 1,268 | | | $34 | $115.00 | $0 | $115 |
| 14 | San Jose | CA | 873,300 | 1,539 | | | $7 | $206.29 | $0 | $206 |
| 15 | Seattle | WA | 543,700 | 2,706 | | | $30 | $120.78 | | $121 |
| 16 | Visalia | CA | 92,677 | 1,009 | $61 | $29 | $24 | $114.19 | $0 | $114 |
| 17 | Worcester | WA | 169,759 | 1,696 | | | $5 | $54.06 | $0 | $54 |
| | | Min = | 1,908 | | $7 | $0 | $1 | $39 | $0 | $31 |
| | | Median = | 92,677 | | $61 | $14 | $16 | $115 | $2 | $115 |
| | | Max = | 873,300 | | $115 | $100 | $75 | $206 | $17 | $206 |
| | | Min if >0 = | | | | | | | $5 | |
| | | Median if >0 = | | | | | | | $12 | |
| | | Data count if >0 = | | | | | | | 8 | |
| | | Percent of data >0 = | | | | | | | 47% | |

# Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Household Density (n=17 municipality sample 1996)



# Exploratory Comparison Between Average Recycling Cost ($/ton) & Municipal Population (n=17 municipality sample 1996)



# Appendix C:
# Four Alternative EMRAD Study Plans (Options) for This Assessment

## Alternative Approaches for Evaluating the Economic Feasibility (Benefits & Costs) of Achieving 35% National Goal for Municipal Solid Waste Recycling

| Level of Effort | OPTION 1: Minimum data/analysis | OPTION 2: Enhanced data/analysis | OPTION 3: Expanded data research & analysis | OPTION 4: National economic benefit-cost analysis |
|---|---|---|---|---|
| Who performs work? | ! EMRAD in-house (Eads)<br>! MISWD only transmits MSW data/info materials (reports, memos, spreadsheets) to EMRAD | ! EMRAD in-house (Eads)<br>! MISWD supports EMRAD through in-house team meetings with EMRAD to inform/steer data collection and analysis | ! EMRAD or contractor performs worktasks<br>! MISWD supports EMRAD on consultation basis such as for drafting supplementary pieces, and/or as WAM for contractor. | ! Contractor performs all worktasks<br>! EMRAD or MISWD directs/ reviews work as contractor WAM. |
| FTE duration | ! 2 to 4 weeks | ! 4 to 8 weeks (depends upon level of data and info details discovered/desired) | ! 8 to 12 weeks | ! 16 to 36 weeks (or longer) |
| Data Collection | ! MISWD staff.<br>MISWD provides EMRAD with relevant materials (e.g. EPA reports, internal memos, gray literature, etc.), concerning MSW recycling in general, and concerning OSW 's 35% goal in particular. | ! EMRAD & MISWD staff.<br>(A) EMRAD conducts verbal interiews with MISWD staff to collect information on prior MSW recycling topics in general, and on OSW's 35% goal in particular (e.g. prior stakeholder meetings, prior conference calls with regions/ states, prior internal analyses, prior EPA studies, and prior published or gray literature studies by academics, NGOs, states, municipalities).<br>(B) EMRAD participates in upcoming MISWD RIT conference call (25 March): (1) to describe OSW's new economic analysis project options concerning the 35% goal, and (2) to leverage regions for feedback/ suggestions/ inputs (an opinion poll approach). | ! EMRAD in-house or contractor:<br>(A) Collect data as described in Option 2.<br>(B) Search internet and published literature for additional materials relevant to MSW recycling economics. | ! Contractor:<br>(A) Collect extant data per Option 3.<br>(B) Collect new data as necessary (e.g. survey <10 entities each of municipal govt's, recycling companies, MSW collector companies).<br>(C) Transfer or otherwise formulate reasonable assumptions to plug data gaps (numerical single point values or numerical uncertainty ranges). |
| Output | ! EMRAD drafts 10 to 20 page briefing package containing inventory of information sources, data gaps, possible conclusions about 35% goal, and list of options for expanded economic analysis.<br>! MISWD reviews/ edits package.<br>! EMRAD & MISWD present briefing to OSW management for decision about next step options. | ! EMRAD drafts 10 to 50 page briefing package to present verbally to OSW management in early or late April 2003 meeting.<br>! MISWD reviews/ edits package.<br>! Package contains overview of existing data/info & gaps, findings about economic feasibility of 35% goal, and any next steps for OSW management decision. | ! EMRAD in-house or contractor:<br>Prepare a draft briefing package as described in Option 2, supplemented with extramural data/ information materials. | ! Contractor:<br>(A) Deliverable #1: Draft a comprehensive report (100 to 300 pages) describing data sources, methodology, findings, and recommendations of this study.<br>(B) Deliverable #2 (optional): Draft a 10 to 50 page briefing package for use by EMRAD and MISWD to present the study findings and national policy options to OSW management. |
| Types of MSW recycling policy questions addressed | ! What is origin/rationale behind OSW's 35% goal?<br>! What analytic options does OSW have to evaluate the 35% goal? | ! Is the 35% goal economically feasible?<br>! Is there a more appropriate MSW recycling goal?<br>! What are OSW's policy options for achieving 35% (e.g. which waste categories to target, how to provide market incentives)? | ! What are the characteristics of the US national MSW recycling market(e.g. tons/year recycled, count of recycling entities, waste types recycled, recycled material prices, recycling costs, recycling budgets, regional or major municipal differences in recycling market)? | ! What are national aggregate annual benefits & costs associated with achieving the 35% goal?<br>! What are the disaggregate benefits & costs (e.g. by waste category, by reuse industry, by region, by major municipality), and associated feasible contribution towards the 35% goal?<br>! What are the technical constraints to the 35% goal?<br>! How many years may it take to achieve the 35% goal?<br>! What is the gap between private & social benefits/costs? |